A Q U A P H Y T E

A Newsletter about Aquatic, Wetland and Invasive Plants

Center for Aquatic and Invasive Plants
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To Be or Not To Be:

Assessment Methods and Invasive Plant Prediction Models

Land managers, facing increasing non-native species and exploding non-native plant abundance, obvious to all, want help beyond mere anecdotes and generalizations; managers are in urgent need of at least two tools: 1) a **predictive method** (a screening protocol) that enables managers to know in advance which non-native plants will remain prettily in the yard, and which are likely to escape their domestic confines and invade natural areas; and 2) an **assessment method** that makes it possible to classify and prioritize already-in-place non-native plants according to their invasiveness.

Being able to predict plant invasiveness, and being able to classify existing non-native plants

- would enable regulators to allow or prohibit certain species;
- would enable eco-managers to determine which areas should be regularly surveyed so that new invasions might be quickly controlled;
- would enable eco-managers to develop and employ smarter plant management strategies to reduce environmental damage;
- would help nurserymen, retailers and their customers who want to enjoy plants that are from somewhere else; and
- would inform plant-buying consumers so that they, too, can join the fray against non-native plant invasions.

What progress have scientists made in developing predictive methods and assessment means? The first place one might look is the **APIRS** database, an expanding 65,000-item collection of the scientific literature about invasive plants in Florida, the US and beyond. (Go to: http://plants.ifas.ufl.edu/ - click on "**APIRS** Online Database.")

The **APIRS** bibliographic database includes more than 250 research articles and books that include variations of the keywords, "assess," "predict" and "invasiveness." (Many more "abstracts" about the subject are included in dozens of proceedings of management societies, and are listed in **APIRS** bibliographies, but abstracts are not included in the following.)

Among the items listed in **APIRS** are two ambitious assessment methods, the National Assessment and the Florida Assessment.

National Assessment

The national assessment protocol is the work of NatureServe, The Nature Conservancy and the National Park Service. Its purpose is to "make the process of assessing and listing invasive plants objective and systematic," and is used to assess species individually for a specified "region of interest." This protocol is being used to "assess the biodiversity impact of the approximately 3,500 non-native vascular plant species established outside cultivation in the United States."

Of the 3,500 plant species targeted for assessment, 382 are complete and may be downloaded. (These 382 assessments are included in the 2,052 page PDF file.)

The national assessment classifications include "National I-Rank," "Ecological Impacts," "Current Distribution," "Trend in Distribution" and "Management Difficulty." The national assessment protocol was authored by L.E. Morse, J.M. Randall, N. Benton, R. Hiebert and S. Lu, 2004.

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Mary's Picks!

Items throughout this issue marked with "" are from articles that particularly piqued the interest of Mary Langeland, the reader/cataloger for the **APIRS** database.*

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* **Fruits and seeds of *Ruppia* (Potamogetonaceae) from the Pliocene of Yushe Basin, Shanxi, northern China and their ecological implications.** 2004. By L.-C. Zhao, M.E. Collinson and C.- S. Li. *Botanical Journal of the Linnean Society 145:317-329.*

This reports the discovery of fossil fruits and seeds from monotypic stands of *Ruppia* in northern China dating from 3.5 to 2.3 million years ago. Their presence apparently indicates the existence of a temperate climate in this area. The discovery also increases the range of *Ruppia* from Europe to eastern Asia.

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Florida Assessment

The Florida assessment protocol is the work of collaborators from the University of Florida, Santa Fe Community College (Gainesville, Florida) and The Nature Conservancy. The purpose of the Florida assessment is to impartially classify hundreds of non-native plants in our state, by area (North, Central and South zones). The result is that many non-native plants are deemed "OK" to be recommended for use in certain zones of the state. The original purpose of the assessment was to conform university publications so that Extension and other university workers were giving consistent information to the public regarding the use of non-native plants.

The authors stress this is not a predictive instrument but is intended only for plant species or cultivars that currently occur within Florida. Species not yet introduced to Florida "would require a separate predictive instrument, still to be developed." Of the 193 species selected for assessment, 159 are complete and may be downloaded.

The IFAS Assessment classifications include

"Not eligible for any uses" (61 plants);

"May be eligible for limited uses if approved by the Invasive Plant Working Group" (19 plants);

"Caution: may be recommended but manage to prevent escape" (37 plants);

"Not a problem species, but has been documented in undisturbed natural areas" (42 plants); and

"Not a problem species, and has not been documented in undisturbed natural areas" (87 species).

Another 34 plants are "not yet assessed" or are "in progress."

The Florida assessment protocol was authored by A.M. Fox, D.R. Gordon, J.A. Dusky, L. Tyson and R.K. Stocker, 2005, University of Florida.

Both the National and Florida assessments are online, and include PDF files of their method protocols, field survey forms, and results lists of non-native plants that are believed to be invasive. The national list includes completed US national assessments for 382 plant species; the Florida list includes completed assessments for 158 plant species.

NatureServe U.S. Invasive Species Assessment Protocol and Results: http://www.natureserve.org/getData/plantData.jsp

IFAS Assessment of the Status of Non-Native Plants in Florida's Natural Areas Protocol and Results: http://plants.ifas.ufl.edu/assessment.html

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Current Prediction and Assessment Literature Found in the APIRS Database

The first flurry of research about predictive models and invasive plant assessment methods appear in the **APIRS** database from the mid-1980s. Ten years later came the next small batch of "prediction" research. Then for 2000 the database reported 12 research items about invasive plant predicting; in 2001 there were 28; in 2002, 22...

One thing is clear from looking at these papers: there are a number of methods for counting plants in a big area, there is some good information about the morphology and physiology of many non-native plants and what climates they prefer, etc., **but there seems to be little usable science for the land manager** whose job it is to beat back the hundreds of invading plant species.

By the mid 1980s, plant researchers were asking questions they felt would be useful in creating a predictive mathematical model, such as: "do invading species have definable genetic characteristics?" At the same time, other scientists had decided that models cannot be as good as empirical evidence ("what we've seen a plant do before provides a good indication of what it will do again"). Roughgarden (1986) said that we can "make just as good a prediction, though perhaps restricted to the short term, by using ad hoc methods requiring less work" than model building and testing. Thus, strong pants and shoes, a compass, a map and pen, and the willingness to walk, will yield information for a good prediction. However, "if the community that is to be invaded is itself sufficiently variable, then predicting anything about an invasion will assume the status of a weather report."

By the end of the 1990s, scientists were trying to create useful predictive models using site characteristics, species characteristics and environmental disturbances (Clarke, 2002). In 1999, Goodwin found that the original range alone was an effective predictor - to 70% accurate. But he concluded that "prediction of invasiveness on a species-by-species basis is not likely to help stem the flow of accidentally introduced invasive species."

Was significant progress made between 1980 and 1999? See Rejmanek (2000) for a review of predictive approaches. See Werren (2001) for reviews of Risk Assessment Systems (RASs); he was looking to screen non-native species to identify and control the "sleeper weeds" - i.e. plants in the initial stage of invasion - "before their rate of spread is exponential."

More recently, a scant few researchers have worked on ways to predict invasions and to assess non-native plants already in new ranges:

- the **Weed Invasion Susceptibility Prediction (WISP)** model was 85% to 97% accurate for individual rangeland species (Gillham, 2004);

- the **US Geological Survey** ranking system, a "semiquantitative ranking system," was used to classify 167 species into four invasive categories (Drake, 2002);

- the **Rapid Ecological Assessment** method was evaluated by Krauss (2003);

- the **Genetic Algorithm for Rule-set Prediction,** the "ecological niche model" called **GARP**, developed models on native geographic distribution and projected them to other regions to "predict the geographical potential of species' invasions with high accuracy" (Peterson, 2003);

- the authors believe Australia's robust, simple, and understandable **National Significance Assessment System** to be the "first ever attempt at devising a generic scoring system to rank the importance of established weeds on a national basis"; with it they listed Australia's 25 most significant invasive plants (Virtue, 2001);

- and Pysek (2004), in search of a reliable predictor, says that it's important to distinguish between archaeophytes (plants introduced by man to a new area as long ago as several thousand years) and neophytes (more recent introductions), and that archaeophytes should be considered non-native plants for modelling purposes.

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*Following are articles on prediction and assessment of invasive plants from refereed journals and books, in ascending order by year. **APIRS** also lists many more abstracts and shorts from proceedings of various invasive plant societies.*

1958 (republished 2000) - Elton, CS. The Ecology of Invasions by Animals and Plants. University of Chicago Press. 181 pp.

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1986 - Mollison, D. Modelling biological invasions: chance, explanation, prediction. Phil. Trans. R. Soc. London. B314(1167):675-692.

1986 - Mooney, HA; JA Drake, Eds. Ecology of Biological Invasions of North America and Hawaii. Ecological Studies 58, Springer-Verlag, New York, 321 pp.

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1998 - Starfinger, U. On success in plant invasions. In: Plant Invasions: Ecological Mechanisms and Human Responses, Eds. Starfinger, U; K Edwards, I Kowarik and M. Willamson, Backhuys Publ., Leiden, The Netherlands, pp. 33-42.

1999 - Goodwin, BJ; AJ McAllister; L Fahrig. Predicting invasiveness of plant species based on biological information. Conserv. Biol. 13(2):422-426.

1999 - Hengeveld, R. Modelling the impact of biological invasions. In: Invasive Species and Biodiversity Management, Eds. OT Sandlund et al; Kluwer Academic Publishers, Boston, pp. 127-138.

1999 - Kan, T. Where the wild weeds are: the value of a rapid assessment of invasive weeds. California Exotic Pest Plant Council News 7(3-4):7-8.

1999 - Madsen, JD. Predicting the invasion of Eurasian watermilfoil into northern lakes. Tech Rept. A-99-2, 36 pp., US Army Corps of Engineers, Waterways Expt. Station, Aquatic Plant Control Research Program, Vicksburg, MS.

1999 - Malakoff, D. Biological invaders sweep in. Science 285:1834-1843.

1999 - Rozefelds, AC; R Mackenzie. The weed invasion in Tasmania in the 1870s: knowing the past to predict the future. 12th Australian Weeds Conf, Papers & Proc., 12-16 Sept, Hobart, Tasmania, pp. 581-583.

1999 - Stocker, RK. Standardizing invasive plant assessment methods for field inventory. In: Proc. 1998 Joint Symp. Florida Exotic Pest Plant Council and Fl. Native Plant Soc., June 4-7, 1998, Eds DT Jones and BW Gamble, pp. 23-33.

1999 - Williamson, M. Invasions. Ecography 22(1):5-12.

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*** Plant invasion ecology - dispatches from the front line.** 2004. By D.M. Richardson. *Diversity and Distributions 10(5-6):315-319.*

Mary calls this "a thoughtful and broad-ranging editorial" about biotic invasions, biotic resistance, manipulative experiments, modelling and impacts.

*** *Archaefructus* - angiosperm precursor or specialized early angiosperm?** 2003. By E.M. Friis, J.A. Doyle, P.K. Endress and Q. Leng. *Trends in Plant Sciences 8(8):369-373.*

The authors are skeptical that *A. lianoningensis* is the oldest known angiosperm. They think *Archaefructus* "might be a crown-group angiosperm specialized for aquatic habit rather than a more primitive relative."

*** Seed germination responses of *Monochoria korsakowii* Regel et Maack, a threatened paddy weed, to temperature and soil moisture.** 2004. By X.-C. Wan, G.-X. Wang and I Washitani. *Plant Species Biology 19:203-207.*

What were once common paddy weeds have now become protected species. Here's a report on one of them. The authors conclude that *M. korsakowii* has declined because it has not adapted to today's farming system in Japan, which includes laying rice fields fallow and the use of herbicides.

*** Blitzkrieg in a marine invasion: *Caulerpa racemosa* var. *cylindracea* reaches the Canary Islands (north-east Atlantic).** 2004. By M. Verlaque, J. Afonso-Carrillo, M. C. Gil-Rodriguez, et al. *Biol. Invasions 6(3):269-281.*

An invasive variety of this species, introduced from Australia to the Mediterranean Sea, now has been found in the Canary Islands. The finding in proximity to harbors supports the hypothesis of possible dispersal by ship traffic. Other parts of the world could soon become infested without more control on the aquarium trade and ships, according to the authors.

*** How interactions between ecology and evolution influence contemporary invasion dynamics.** 2004. By J.G. Lambrinos. *Ecology 85(8):2061-2070.*

The author states that "invading populations often experience rapid evolutionary changes associated with or soon after their introduction." The genetics of the invading plants can be altered by founder effects, drift, interbreeding and hybridization, local adaptation, migration and dispersal patterns, strong selectivity, human dispersal and landscape change. This article reviews previous research that focused on these issues.

*** Astroturf seed traps for studying hydrochory.** 2004. By M. Wolters, J. Geertsema, E.R. Change, R.M. Veeneklaas, et al. *Functional Ecology 18(1):141-147.*

Seed dispersal by water (hydrochory) "is an important aspect of the vegetation dynamics of plant species growing near streams, rivers, oceans and seas." Described here is a new method for collecting seeds and other propagules as they drift and disperse in tidal marshes.

ALIEN PLANT ENTRY
Some Observations from the West-Central Illinois Flora

by Dr. Robert Henry, Retired Curator of the RM Myers Herbarium, Ohio State University

Flora authors have observed and recorded alien plants probably since the beginning of plant records. The presence of aliens in a flora is documented by records and collections, but these may not be accurate or complete and therefore, do not necessarily represent the actual time of entry. Most data are post-European settlement. However, Native Americans, European and other pre-settlement explorers, traders, trappers, itinerants and temporary homesteaders could, by their inter- and intra-continental activities and movements, provide ample opportunities for alien plant entry and establishment. Also, alien propagules could arrive by air, water and animals before and after human presence. This essay presents some composite observations concerning alien plant entry during the period of 1833 (post-settlement) to 1987 into the west-central Illinois spontaneous or non-cultivated vascular flora. The time of the first entry of an alien plant into the west-central Illinois flora is unknown.

Systematics

During this period, the alien plants have always been and still are mostly angiosperm (99%) dicots (79%). The plant families with the most species are: Poaceae, Asteraceae, Brassicaceae, Fabaceae, Malvaceae, Chenopodiaceae, Amaranthaceae, and Lamiaceae. By 1987 aliens were in 43% of the families and 8% of the families were all aliens. *Chenopodium, Rumex, Malva, Amaranthus*, and more recently *Bromus, Brassica* and *Polygonum* are a few of the genera with the most aliens. By 1987 aliens were in 38% of the genera and 24% of the genera were all aliens.

Floristics

Increasing numbers of aliens in the flora is indicated by six percent in 1846 to 25% by 1987. From 1846 to 1952 there was one alien species average increase per year, whereas from 1953 to 1987 there were about three. The geographical origin has been consistently and predominately European, being from 74% to the present 82%. The western United States is the source of most aliens from within this country. Deliberate introductions, most being cultivated, have been about 50%, leaving spontaneous occurrences at about 50%. Naturalization of alien species has increased from zero percent from the original entries to about 80% now.

Ecology

The alien species have been 98% terrestrial, with about 25% of all terrestrial species alien. Aquatic alien species were few (1%) early and now only about two percent of the alien species are aquatic, with six percent of all aquatic species being alien. Almost all alien species occur on disturbed land (disturbophytes). Land cover is over 90% alien species, principally due to agriculture. There is an interesting paradox regarding the attitude toward alien plants: The effort to eradicate alien weedy plants vs. the effort to propagate alien food plants (corn, soybeans, etc) and other utilitarian species on the same land. Forty-six percent of alien species are considered weeds and 40% of weed species are aliens. Of alien weed species in Hancock County, IL, 47% were once cultivated, 85% are from the Old World, 44% were in the county before 1881, and between 1833 and 1978 one species was introduced per year. 13% of woody weed species were alien, and 40% of herbaceous weed species were alien. Most alien species are annual and biennial (56%), while 50% of annuals are alien. Most alien species are herbaceous (88-94%). The number of woody species has doubled (6-12%) including ill-advised plantings such as *Elaeagnus* spp., *Rosa multiflora*, and *Lonicera* spp. promoted by government entities. The latter two are now illegal to sell and plant in Illinois. Twenty-five percent of all herbaceous species and 22% of woody species are alien.

Once arrived, alien species have often become detrimental to the ecosystem as has been extensively documented. Aliens are increasingly occupying disturbed and natural areas, becoming naturalized and causing a rapid change in vegetation cover and in flora composition, causing more native species to be rare, threatened, endangered and possibly extinct. As urbanization (including urban sprawl), industrialization, transportation, recreation, agriculture (including bioengineered species), clearing and extraction increase, so does disturbed land with alien species, including alien weeds. The potential for alien species to become weeds is not static but varies with time and environmental conditions. Climate change could favor aliens also. We probably can expect the percent of alien species to increase and their geographical origin to vary as the flora becomes increasingly homogenized due to introductions both purposeful and accidental as a result of world commerce. Although most alien immigrants in the near future will continue to be angiosperms, terrestrial, and herbaceous, this could change in the future.

There is now a rapid increase in our interest and awareness of alien species and their effects on both the native species in our ecosystems and the functioning and beneficial services of these ecosystems. In earlier times, alien floristic data was presented to document what was occurring in the flora, but response was limited, perhaps due to the fact that the data were floristic and local; they did not stress the present overall ecological/ecosystem deterioration paradigm that is the basis of the current interest in invasive alien plants.

To decrease or prevent future alien entry, purposeful introductions are being more closely monitored and regulated and a major effort is being made to reduce accidental entry especially along transportation corridors. Of the recent alien entries in one west-central Illinois county, 68% entered along railroad and highway corridors, locations where disturbed habitats and other environmental parameters are conducive to alien establishment. Many of the early alien species were purposely introduced to meet settlers' needs for food and other utilitarian and cultural uses, which then escaped and became naturalized. We still, and will continue to need native and alien species for these uses. Wildlife commonly uses alien species present in their habitat. Alien entry most likely will not be stopped and the ones already present will not be eradicated. A more efficient use of the enormous money and labor being spent is needed in their management, which should include a tolerable objective threshold that is productive, useful, beneficial and compatibly integrated with the dynamic flora of the ecosystem.

> *"An informal survey indicates that no American taxonomists are specialists on alien plants and that few are much concerned about the status of aliens in [published] floras." 1979.*
>
> From **Changes in the alien flora in two west-central Illinois counties during the past 140 years** by RM Myers and RD Henry, *American Midland Naturalist 101(1):226-230.*

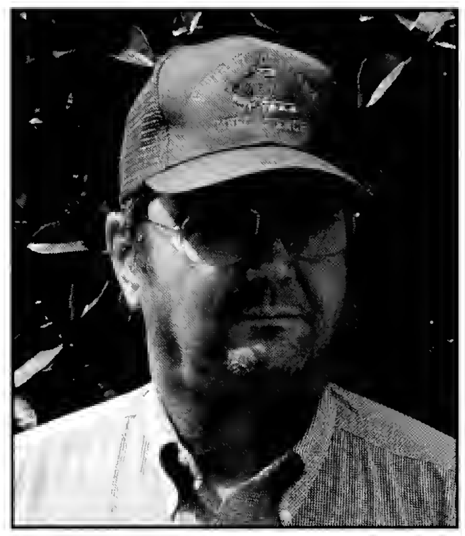
DEP - IFAS Review of Aquatic and Invasive Plant Research in Florida

Aquatic and invasive plant research being performed throughout Florida was reviewed in Gainesville recently as the **Florida Department of Environmental Protection (DEP), Bureau of Invasive Plant Management**, and the **University of Florida, Institute of Food and Agricultural Sciences (UF-IFAS), Center for Aquatic and Invasive Plants** hosted a meeting to review current research being funded by the state agency and UF-IFAS. Other objectives were to communicate ideas and needs for future research on aquatic and invasive plants in Florida.

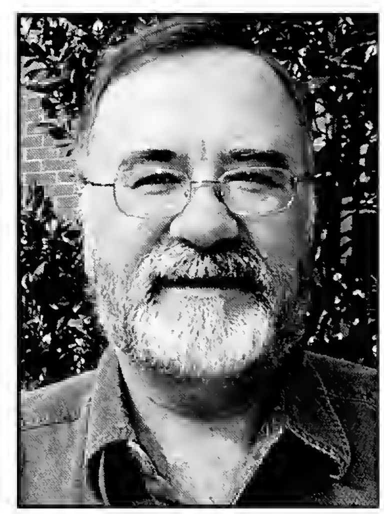
William Torres, Chief of the DEP Bureau of Invasive Plant Management, and **William Haller**, Acting Director of the Center for Aquatic and Invasive Plants welcomed invasive plant scientists from throughout Florida to the one and a half day gathering. **Don Schmitz**, Biologist and Research Contract Manager for the Bureau, stated in his overview that more than 88 million dollars is spent annually on invasive plants and animals by all of the various state agencies in Florida. Of that 88 million, less than $800,000 is spent on research and outreach. The bulk of the Bureau's money pays for management efforts, with about half going toward hydrilla control. Most research money is spent on biological control with about half of the projects being investigated at UF-IFAS.

Projects covered in the research review included multiple presentations on biocontrol insects being considered for control of *Casuarina* spp., *Hydrilla, Lygodium microphyllum, Schinus terebinthifolius, Paederia foetida* and *Dioscorea bulbifera*. Potential invasiveness of ornamental plant species was reviewed as well as ecological studies of *Scleria lacustris, Imperata cylindrica* and *Hemarthria altissima*. Work on mycoherbicides was reviewed as well as chemical herbicide studies for controlling *Hydrilla, Lygodium* and *Imperata cylindrica*. Mapping and survey research was presented, as was an overview of **APIRS** activities. **APIRS** has been a long-time recipient of DEP and UF-IFAS funding for maintaining and expanding the database and for educational products and services.

DEP areas of current research interest include biological control, improved practices for chemical control, economic impacts, development of screening protocols, and evaluations of mechanical harvesters and tussock shredding machines. High priority species for the current year are *Hydrilla* and *Lygodium microphyllum*. High priority *Hydrilla* research includes tuber formation and viability, grass carp/herbicide combinations, and development of new herbicide tools. High priority *Lygodium microphyllum* objectives are to continue biological control research, determining optimal times for herbicide treatments, finding new herbicide tools, effects of fire, and decontamination methods for workers and equipment in the field for this spore dispersed fern species.



Dr. William Haller,
Acting Director,
Center for Aquatic and
Invasive Plants,
University of Florida, IFAS.



Mr. Don Schmitz, Biologist and
Research Contract Manager,
Bureau of Invasive Plant
Management, Florida Department
of Environmental Protection.

Mr. William Torres,
Bureau Chief, Bureau of
Invasive Plant Management,
Florida Department of
Environmental Protection,

* **Do alien plants reduce insect biomass?** 2004. By D.W. Tallamy. *Conservation Biology18(6):1689-1692*

Considering how important insects are to the food chain, the author asks why so little research has been done to answer important questions about the effects of non-native plants on native insects, questions such as: 1) Many non-native plants were spread by humans because of their unpalatability to insects; as these unpalatable plants spread, what will native insects eat? 2) How many herbivores will associate with a non-native plant compared to the number of herbivores in the plant's native range? 3) Do "generalist" insects do as well on non-native plants as on natives? 4) To what extent do generalist insects eat non-native plants? 5) To what extent does non-native plant abundance affect egg-laying and feeding? 6) How does replacement of native plants with non-native species affect insectivorous mammals, reptiles and amphibians? "Given the pervasiveness of alien plants in North America and the speed with which they continue to replace native vegetation, addressing such questions should become a priority among funding agencies and researchers alike."

* **What makes a weed a weed: life history traits of native and exotic plants in the USA.** 2004. By S. Sutherland. *Oecologia 141(1):24-39.*

The author compared ten life history traits for the 19,960 plant species that occur in the USA. He found that a) life span was the most significant life history trait for weeds - weeds were more likely to be annuals and biennials than perennials; b) weeds were more likely to be wetland adapted, toxic and shade intolerant; and c) weeds were more likely to be monoecious and trees.

Look at the Web Sites, Complete the Crossword, Win a Prize!

The first 10 people (any state, any country) who return the correctly-completed crossword puzzle will win four each of the two laminated ID guides described on page 2. This puzzle can be solved by referring to two web sites: the original **APIRS** web site: *http://plants.ias.ufl.edu* and our new web site: *http://plants.ifas.ufl.edu/guide* Read the clue, refer to the URL cited, find the answer and fill it in. Photocopy your completed crossword puzzle at 100% and send it via snail mail to: CROSSWORD, Center for Aquatic and Invasive Plants, 7922 NW 71 Street, Gainesville, FL 32653, USA.

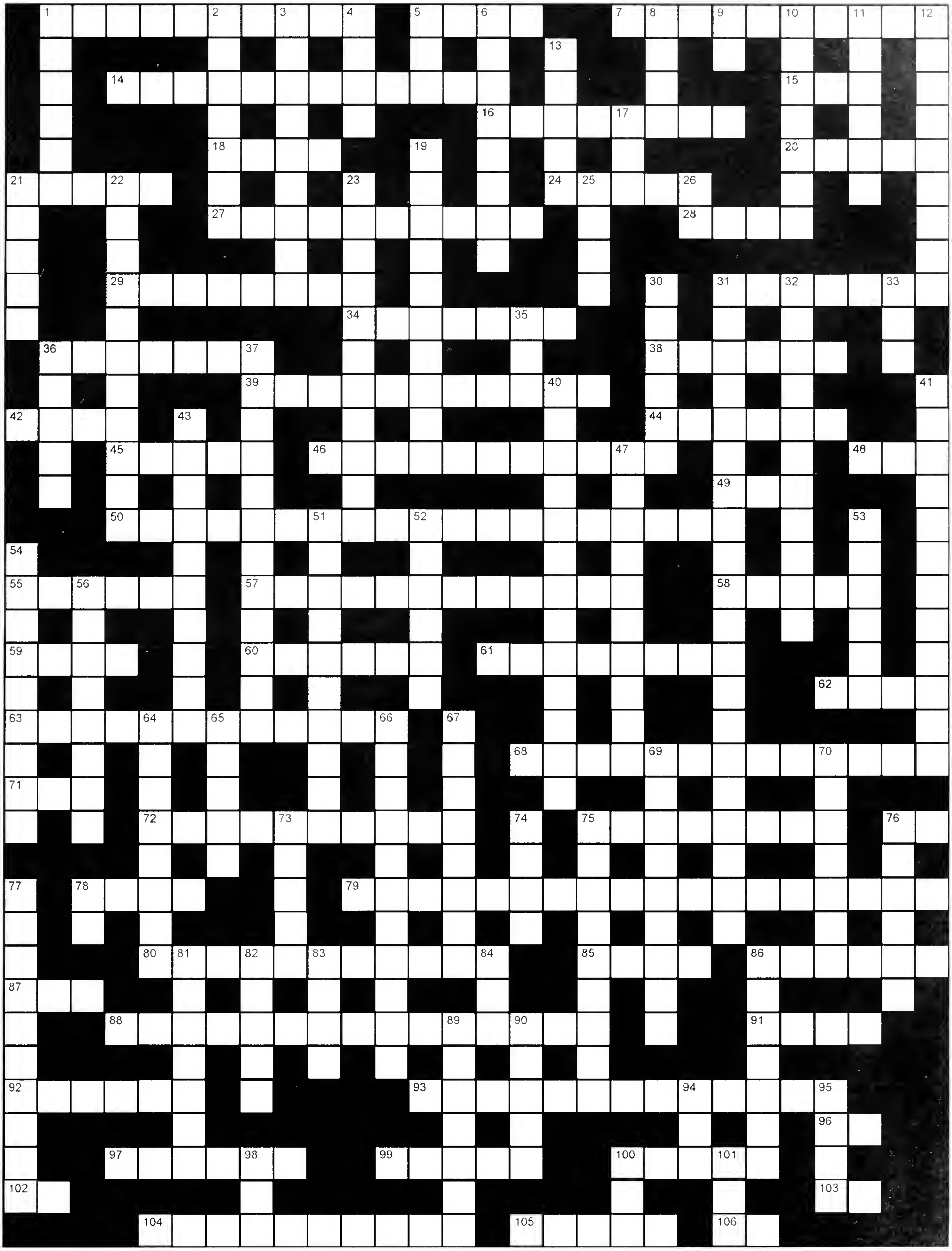
Across

1. salt grass, ________ *spicata*, (...edu/disspi.html)
5. DEP Bureau of Invasive Plant Management
7. banana lily (...edu/photocom.html)
14. *Ipomoea* common name
15. *Dioscorea bulbifera*, ________ potato
16. underwater soil
18. below-ground plant part (...edu/glosin10.html)
20. ______ duckweed, ______salvinia, ______reed
21. upright stems are _________
24. arranged from center (...edu/glosstu.html)
27. *Colubrina asiatica* (...edu/colasi.html)
28. freshwater sportfish (...edu/guide/fish.html)
29. herbicide modifier (...edu/guide/adjuva.html)
31. "________ tolerances" (...edu/l-mental.html)
34. _______ River State Park: colorful! (...edu/gallery2.html)
36. President ________'s Executive Order 13112 (...edu/assessment.html)
38. ________ Prairie State Preserve (...edu/gallery2.html)
39. *Microcystis* is a ________ alga (...edu/guide/2algae.html)
42. Chinese grass _____ (...edu/guide/biocons.html)
44. drink of the gods (...edu/gloss-no.html#n2)
45. measure your _______ width (...edu/guide/calibinf.html)
46. giant cut grass (...edu/zizmil.html)
48. facultative wetland plant (abbr.)
49. ___ World climbing fern (...edu/lygod.html)
50. *Saccharum giganteum* common name (...edu/photos.html)
55. Plant ID chapter (...edu/b-conten.html)
57. section on _______ lakes (...edu/guide/lakes.html#lakdisap)
58. very low nutrients, ________trophic (...edu/guide/trophstate.html)
59. *Xyris* is yellow______ grass (...edu/photos.html)
60. Origin of *Iris pseudacorus* (...edu/iripse.html)
61. cord grasses (...edu/photocom.html)
62. *Sapium, Schinus, Taxodium*...
63. white-flowered wandering Jew (...edu/traflu.html)
68. *Spirodela polyrhiza* common name (...edu/photos.html)
71. 10 million years is a long time ________
72. last subject on this page (...edu/guide/mechcons.html)
75. Cookie Cutter is a kind of ________ (...edu/guide/mechcons.html)
76. milligram (abbr.)
78. 11th lake down (...edu/guide/lakesnor.html)
79. wild petunia (...edu/photocom.html)
80. hyacinths won't grow in freezing ________
85. Florida Extension's "Electronic Data Information Source" (abbr.)
86. 5th mollusc listed under "Endangered Animals" (...edu/guide/endanger.html)
87. hard-shelled dry fruit (...edu/gloss-no.html#n11)
88. *Spartina alterniflora* common name (...edu/photos.html)
91. where skunk vine comes from (...edu/paefoe.html)
92. AKA "the fish hawk" (...edu/guide/birds.html)
93. not from around here (...edu/mcdef.html)
96. University of Florida (abbr.)
97. Florida Exotic Pest Plant Council (abbr.)
99. A river ________ along its course.
100. *Juncus roemerianus*, ________ needlerush (...edu/junroe.html)
102. one ________ equals one gm of water (...edu/o-conver.html)
103. implying removal or reversal
104. water's ability to neutralize acids (...edu/guide/alkaln.html)
105. egg-shaped (...edu/gloss-no.html)
106. weight (abbr.)

Down

1. EPA's highest level advisory language on herbicide labels - go to guide, click on keyword "labels"
2. maintenance ________ of plants (...edu/guide/sup1herb.html)
3. _________ *punctata* = *Spirodela punctata* (...edu/lanpun.html)
4. *Potamogeton pectinatus* = ________ pondweed (...edu/allplants.html)
5. ______logical; ______graphy;
6. hand-pulling and raking are ________ control (...edu/guide/physcons.html)
8. our example of a "solution (sinkhole) lake" (...edu/guide/lakes.html)
9. acidity scale (...edu/guide/ph.html)
10. Florida's most valuable non-native plants (...edu/guide/agricul.html)
11. "pertaining to the back" (...edu/gloss-de.html#d26)
12. shaped like an arrow-head (...edu/gloss-html#s2)
13. first one in row of pictures (...edu/guide/invplant.html#invvine)
17. a large disorderly crowd
19. duckweed of starlike colonies (...edu/wolflo.html)
21. number of herbicide compounds registered for use in Florida (...edu/guide/herbcons.html)
22. fifth tree in the row (...edu/treplants.html)
23. "hyacinth ________ boat" 1939 (...edu/guide/mechcons.html)
25. what water hyacinth is to a water hyacinth weevil; breakfast, lunch, dinner
26. pound (abbr.)
30. torpedograss, ________ *repens*
31. inundated beakrush (...edu/rhyinu.html)
32. the green word: (...edu/guide/invplant.html#invsteward)
33. Uniform Resource Locator (abbr.)
35. wetland code for plant that lives in water
36. sandhill; whooping (...edu/guide/birds.html)
37. spatterdock (...edu/photocom.html)
40. West Indian marsh grass, *Hymenachne* ________
41. common name of *Pontederia cordata*
43. a rush with leaf blades, *Juncus* __________ (...edu/photos.html)
47. agricultural canals are used for flood control and for ________ (...edu/guide/canals.html)
51. attracting to a surface; a possible fate of aquatic herbicides in the environment (...edu/l-mental.html)
52. Brazilian ________ tree, *Schinus terebinthifolius*
53. *Marsilea* is water ________
54. endangered plant, *Nemastylis floridana*, _______ lily (...edu/guide/endanger.html)
56. "________ boat", 1914 (...edu/guide/mechcons.html)
64. *Pennisetum purpureum*, ________ grass
65. caric sedges, ________ species (...edu/photocom.html)
66. Florida's second largest industry at $6.85 B (...edu/guide/assets.html)
67. "time-release ________ pellets of herbicide" (...edu/guide/mgmtpics.html)
69. turbidity - a measurement of water clarity
70. EPA's mid-level advisory language on herbicide labels - go to guide, click on keyword "labels"
73. national bird, bald ________
74. *Zephyranthes atamasco*, ________ lily (...edu/photos.html)
75. hydrilla is a _______ (underwater) plant
76. go to Guide; click on "Map of public waters..."; click on Leon County; read Lake _______, 255 acres
77. genus for camphor tree. on APIRS web site, click on "401 Native and..."; click on "Plant type category"; click on "Trees"; find "camphor"
78. ounce (abbr.)
81. ...edu/p-words.html. 37th definition - "A population wthin a species..."
82. ...edu/guide/springpics.html. 2nd column, 6th springs down: _______ Springs
83. wild _______ (...edu/zizaqu.html)
84. elephant _______ (...edu/xansag.html)
86. ...edu/guide/springs.html. Under "Some Florida Springs", fourth pic from left: _______ Springs
89. The subject of this page. (...edu/guide/geology.html)
90. acronym: Aquatic, Wetland and Invasive Plant Information Retrieval System
94. About _______-Registration (...edu/guide/sup7herb.html)
95. Accidentally killed plants? Prepare to be _____.
98. pounds per acre (abbr.)
100. *Limnobium spongia*, frog's_______ (...edu/lisppic.html)
101. _______ lily: another common name for *Nuphar advena*. (...edu/floplants.html)

Bonus question for 2 extra plant recognition guides: What do you hear when you go to: http://plants.ifas.ufl.edu ? In left column, click on "Florida Photo Sets," scroll down and click on "Paynes Prairie State Preserve."



FROM THE DATABASE

Here is a sampling of the research articles, books and reports which have been entered into the aquatic, wetland and invasive plant database since Summer 2004.

The APIRS database contains more than 64,500 citations. To use the free database online, go to http://plants.ifas.ufl.edu/ and click on APIRS Online Database.

To obtain articles, contact your nearest academic library, or a document delivery service. Full text of records cited in APIRS is not stored electronically.

ALMEIDA, C.M.R., MUCHA, A.P., VASCONCELOS, M.T.S.D.
Influence of the sea rush *Juncus maritimus* on metal concentration and speciation in estuarine sediment colonized by the plant.
ENVIRON. SCI. TECHN. 38(11):3112-3118. 2004.

ANONYMOUS
Main points of the Invasive Alien Species Act.
MINISTRY OF THE ENVIRONMENT - JAPAN, ONLINE REPORT, HTTP://WWW.ENV.GO.JP/EN/TOPIC/AS.HTML, 2 PP. 2004.

BALATA, D., PIAZZI, L., CINELLI, F.
A comparison among assemblages in areas invaded by *Caulerpa taxifolia* and *C. racemosa* on a subtidal Mediterranean rocky bottom.
MARINE ECOL. 25(1):1-13. 2004.

BARIK, A., BHATTACHARYA, B., LASKAR, S., BANERJEE, T.C.
The determination of n-alkanes in the cuticular wax of leaves of *Ludwigia adscendens* L.
PHYTOCHEM. ANAL. 15(2):109-111. 2004.

BATARY, P., WINKLER, H., BALDI,A.
Experiments with artificial nests on predation in reed habitats.
J. ORNITHOL. 145(1):59-63. 2004.

BENNETT, D.J., COLODNEY, E.
Propagation protocol for lizard's tail (*Saururus cernuus*).
NATIVE PLANTS J. 2(1):44-45. 2004.

BENNICELLI, R., STEPNIEWSKA, Z., BANACH, A., SZAJNOCHA,K., ET AL
The ability of *Azolla caroliniana* to remove heavy metals (Hg(ii), Cr(iii), Cr(vi)) from municipal wastewater.
CHEMOSPHERE 55(11):141-146. 2004.

BOLSUNOVSKY, A.
Artificial radionuclides in aquatic plants of the Yenisei River in the area affected by effluents of a Russian plutonium complex.
AQUATIC ECOLOGY 38(1):57-62. 2004.

BORNMAN, T.G., ADAMS, J.B., BATE, G.C.
The influence of floodplain geohydrology on the distribution of *Sarcocornia pillansii* in the Olifants Estuary on the west coast, South Africa.
J. ARID ENVIRONMENTS 56(4):603-625. 2004.

BULL, J.S., REED, D.C., HOLBROOK, S.J.
An experimental evaluation of different methods of restoring *Phyllospadix torreyi* (surfgrass).
RESTORATION ECOLOGY 12(1):70-79. 2004.

BURNS, J., JOYNER, J., PAERL, H., SHAW, G.
Evaluation of the production and toxicity of *Lyngbya* spp. in Florida springs.
15TH ANNUAL CONF., FLORIDA LAKE MANAGE. SOC., EDS. HARPER, H.H., AND DARLING, S.H., TAMPA, FL, SESSION 8, P. 5. 2004.

BUSCH, J., MENDELSSOHN, I.A, LORENZEN, B., BRIX, H., ET AL
Growth responses of the Everglades wet prairie species *Eleocharis cellulosa* and *Rhynchospora tracyi* to water level and phosphate availability.
AQUATIC BOTANY 78(1):37-54. 2004.

CHEN, L.J., LEE, D.S., SONG, Z.P., SUH, H.S., ET AL
Gene flow from cultivated rice *(Oryza sativa)* to its weedy and wild relatives.
ANNALS OF BOTANY 93(1):67-73. 2004.

CIRUJANO, S., CAMARGO, J.A., GOMEZ-CORDOVES, C.
Feeding preference of the red swamp crayfish *Procambarus clarkii* (Girard) on living macrophytes in a Spanish wetland.
J. FRESHWATER ECOLOGY 19(2):219-226. 2004.

COFFMAN, G.C., KNIGHT, R.
Giant reed eradication project would provide economic benefits to impoverished communities (South Africa).
ECOL. RESTORATION 22(2):146-147. 2004.

COLAUTII, R.I., MACISAAC, H.J.
A neutral terminology to define 'invasive' species.
DIVERSITY DISTRIB. 10(2):135-141. 2004.

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Innovative uses of vegetated drainage ditches for reducing agricultural runoff.
WATER, SCIENCE, & TECH. 49(3):117-123. 2004.

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Spatial variability of the decomposition rate of *Schoenoplectus tatora* in a polluted area of Lake Titicaca.
J. TROPICAL ECOL. 20(3):325-335. 2004.

COWELL, B.C., DAWES, C.J.
Growth and nitrate-nitrogen uptake by the cyanobacterium *Lyngbya wollei*.
J. AQUAT. PLANT MANAGE. 42:69-71. 2004.

CUDA, J.P., BRAMMER, A.S., PEREIRA, R.M., BROZA, M.
Interference of natural regulation of the aquatic weed mosquito fern *(Azolla caroliniana)* by the red imported fire ant.
AQUATICS 26(2):20-26. 2004.

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An allee effect at the front of a plant invasion: *Spartina* in a Pacific estuary.
J. ECOLOGY 92(2):321-327. 2004.

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Vegetation of upper coastal plain depression wetlands: environmental templates and wetland dynamics within a landscape framework.
WETLANDS 24(1):23-42. 2004.

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Diel variation in methane emissions from the stands of *Carex lasiocarpa* and *Deyeuxia angustifolia* in a cool temperate freshwater marsh.
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Water use by black wattle (*Acacia mearnsii*): implications for the link between removal of invading trees and catchment streamflow response.
S. AFR. J. SCI. 100(1):40-44. 2004.

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Intercontinental similarities in riparian-plant diversity and sensitivity to river regulation.
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ELLISON,C.A., BARRETO,R.W.
Prospects for the management of invasive alien weeds using co-evolved fungal pathogens: a Latin American perspective.
BIOLOGICAL INVASIONS 6(1):23-45. 2004.

EWE, S.M.L., OVERHOLT, W.A., MORGAN, E.C., DIAZ, R., ET AL
A potential biocontrol agent of West Indian marsh grass (*Hymenachne amplexicaulis* (Poaceae)): documenting the impacts of *Ischnodemus variegatus* (Hemiptera: Blissinae) on the photosynthesis and growth of the invasive exotic grass.
WEST OF EDEN - WHERE RESEARCH, POLICY AND PRACTICE MEET, SOUTHEAST EPPC AND FLORIDA EPPC, APRIL 28-30, 2004., PENSACOLA BEACH, FL, P. 26 (POSTER). 2004.

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Effects of seed ingestion and herbivory by waterfowl on seedling establishment: a field experiment with wigeongrass *Ruppia maritima* in Donana, South-west Spain.
PLANT ECOL. 173(1):33-38. 2004.

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A new neotropical species of *Clinodiplosis* (Diptera: Cecidomyiidae) injurious to alligatorweed, *Alternanthera philoxeroides* (Amaranthaceae).
PROC. ENT. SOC. WASH. 106(2):305-311. 2004.

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Hydroponic study of aluminum accumulation by aquatic plants: effects of fluoride and pH.
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Lake Panasoffkee restoration plan: dredging to restore fisheries habitat and restore the historic shoreline.
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Effects of macrophytes on lake eutro-phication and restoration in relation to lake morphometry.
IN: ABSTRACTS, 88TH ANNUAL MEETING ECOL. SOC. OF AMERICA. 2004.

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Initial findings from experimental introductions reveal clues for restoring an endangered wetland grass (California).
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Seed germination in wild celery, *Vallisneria americana* Michx. from Lake Okeechobee, Fla, U.S.A.: preliminary experimental results.
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Induction of high affinity phosphate transporter in the duckweed *Spirodela oligorrhiza.*
PHYSIOLOGIA PLANT. 120(1):271-279. 2004.

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Grazing by manatees excludes both new and established wild celery transplants: implications for restoration in Kings Bay, FL.
J. AQUAT. PLANT MANAGE. 42:49-53. 2004.

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Recovery of submerged plants from high water stress in a large subtropical lake in Florida, USA.
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Influences of simulated grazing and water-depth on the growth of juvenile *Bolboschoenus caldwellii*, *Phragmites australis* and *Schoenoplectus validus* plants.
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Methane emissions from different vegetation zones in a Qinghai-Tibetan plateau wetland.
SOIL BIOL. & BIOCHEM. 36(5):737-748. 2004.

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Developmental morphology of foliose shoots and seedlings of *Dalzellia zeylanica* (Podostemaceae) with special reference to their meristems.
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*** Impact of rising CO_2 on emissions of volatile organic compounds: isoprene emission from *Phragmites australis* growing at elevated CO_2 in a natural carbon dioxide spring.** 2004. By P.A. Scholefield, K.J. Doick, B.M.J. Herbert, et al. *Plant, Cell and Environment 27:393-401.*

It is hypothesized that feedback loops exist between isoprene emission and global warming. Therefore it is important to know how isoprene emission is affected by CO_2 concentrations, so that a figure can be entered into global warming models. Isoprene is a chemical produced and emitted by plants; it may control the concentration of OH in the atmosphere, and thereby determine the lifetime of methane in the atmosphere, methane being the third most important "greenhouse gas". This experiment shows that isoprene is likely to be reduced under elevated CO_2 levels...

Diversity and Distributions - A Journal of Conservation Biogeography

- edited by D.M. Richardson

Diversity and Distributions is a journal that publishes papers on a wide range of themes relating to the study of biodiversity. The journal is billed as "a key forum for research on the ecology of biological invasions." Published by Blackwell Publishing and launched in 1998, the journal is published in six issues per year.

Diversity and Distributions includes full-length research papers and reviews as well as short essays on biodiversity from particular disciplinary, regional, political or other standpoints.

For more information, visit the Blackwell Publishing website at: www.blackwellpublishing.com and click on Journals. A limited number of papers and abstracts are available for viewing free of charge.

*** Invasive species: the search for solutions.** 2004. By C.L. Dybas. *BioScience 54(7):615-621.*

This reporter's timely article reviews the views of the foremost U.S. invasive species scientists - invading species really are a problem!

*** Causes and consequences of invasive plants in wetlands: opportunities, opportunists and outcomes.** 2004. By J.B. Zedler and S. Kercher. *Critical Reviews in Plant Sciences 23(5):431-452.*

This is an extensive review of wetland invasive plants.

*** The Lantana mess - A critical look at the genus in Florida.** 2004. By R.L. Hammer. *The Palmetto 23(1):21-23.*

"Avoid low-growing, yellow-flowered lantanas entirely," the author suggests. Figuring out the taxonomy of lantana in Florida is critical if we are to know which ones to control. Here is the story of one mis-identification after another, by growers and researchers alike.

MEETINGS

April 13-15, 2005; Asheville, North Carolina
SOUTHEASTERN LAKES MANAGEMENT CONF.
http://www.nalms.org/symposia/seconference/index.htm

April 13-15, 2005; Florence, Alabama
ASSOCIATION OF SOUTHEASTERN BIOLOGISTS
http://www.asb.appstate.edu/

April 18-22, 2005; Reno, Nevada
INVASIVE SPECIES CONFERENCE, ASTM
http://peaches.nal.usda.gov/insp/conf.asp

April 16-19, 2005; Alexandria, Virginia
NATIONAL ASSOCIATION OF ENVIRONMENTAL PROFESSIONALS -
http://www.naep.org/

April 27-28, 2005; Tampa, Florida
STORMWATER RESEARCH & WATERSHED MANAGEMENT CONFERENCE -
http://www.mcraeco.com/Stormwater_conf.html

April 26-29, 2005; Chicago, Illinois
EPA- ENHANCING THE STATES' LAKE MANAGEMENT PROGRAMS -
http://www.nalms.org/symposia/chicago/

May 4-6, 2005; Birmingham, Alabama
JOINT MEETING; SOUTHEAST EPPC AND ALABAMA INVASIVE PLANT COUNCIL - http://www.se-eppc.org/

May 5-6, 2005; Florence, Italy
BIOLOGICAL INVASIONS IN INLAND WATERS
http://www.gisp.org/events/showevent.asp?id=201

May 9-11, 2005; Key West, Florida
FLORIDA EXOTIC PEST PLANT COUNCIL
http://www.fleppc.org/

May 12-15, 2005; Melbourne, Florida
FLORIDA NATIVE PLANT SOCIETY
http://www.fnps.org/

May 12-18, 2005; Nebraska City, Nebraska
PROJECT WET ANNUAL CONFERENCE
http://www.projectwet.org/

May 16-20, 2005; Fort Lauderdale, Florida
AQUATIC WEED SHORT COURSE
http://conference.ifas.ufl.edu/aw/

June 6-9, 2005; Duck Key, Florida
FLORIDA LAKE MANAGEMENT SOCIETY
http://flms.net/index.html

June 5-10, 2005; Charleston, South Carolina
SOCIETY OF WETLAND SCIENTISTS
http://www.sws.org/

July 10-13, 2005; San Antonio, Texas
NATIONAL AQUATIC PLANT MANAGEMENT SOCIETY
http://www.apms.org/

July, 2005; Marco Island, Florida
FLORIDA ASSOCIATION OF ENVIRONMENTAL PROFESSIONALS - http://www.faep-fl.org/

July 19-22, 2005; Dubuque, Iowa
IZAAC WALTON LEAGUE NATIONAL CONVENTION
http://www.iwla.org/

July 20-26, 2005; Bethlehem, Pennsylvania
INTERNATIONAL WATERLILY & WATER GARDENING SOCIETY -
http://www.iwgs.org

August 16-17, 2005; Philadelphia, Pennsylvania
MID-ATLANTIC EXOTIC PEST PLANT COUNCIL
http://www.ma-eppc.org/

August 17-19, 2005; Springmaid Beach, South Carolina
SOUTH CAROLINA AQUATIC PLANT MGMT SOCIETY
http://www.scapms.org/

September 8, 2005; Murfreesboro, Tennessee
TENNESSEE EXOTIC PEST PLANT COUNCIL
http://www.tneppc.org

September 11-15, 2005; Anchorage, Alaska
AMERICAN FISHERIES SOCIETY
http://www.fisheries.org/html/index.shtml

October, 2005
MID-SOUTH AQUATIC PLANT MANAGEMENT SOCIETY - http://www.ag.auburn.edu/aquaplant/

October, 2005; South Padre Island, Texas
TEXAS VEGETATION MANAGEMENT ASSOCIATION
http://www.tvma.net/home.htm

October, 2005; Tampa, Florida
ECOSYSTEMS RESTORATION AND CREATION
http://www.hccfl.edu/depts/detp/ecoconf.html

November 8-10, 2005; St. Petersburg, Florida
FLORIDA AQUATIC PLANT MANAGEMENT SOCIETY
http://www.homestead.com/fapms/main.html

November 9-11, 2005; Madison, Wisconsin
NORTH AMERICAN LAKE MANAGEMENT SOCIETY
http://www.nalms.org/

November 29 - December 2, 2005; Lucknow, India
INTERNATIONAL SOC. ENVIRONMENTAL BOTANISTS & NATIONAL BOTANICAL RESEARCH INSTITUTE -
http://www.geocities.com/isebindia/index.html

* **Enzymatic activities in traps of four aquatic species of the carnivorous genus *Utricularia*.** 2003. By D. Sirova, L. Adamec and J. Vrba. *New Phytologist 159:669-675.*

Tiny animals such as mites, rotifers and crustaceans are sucked into the traps (bladders) of bladderworts, thus making meals. This is a study of the digestion of animals inside the traps. The authors found that at least three digestive enzymes are produced, at least partly, inside the traps.

Books/Reports

WATERLILIES AND LOTUSES - Species, Cultivars and New Hybrids, by P.D. Slocum. 2005. 328 pp.

(Published by Timber Press, 133 SW 2nd Avenue, Suite 450, Portland, OR 97204. ISBN 0-88192-684-1. US$34.95 plus S/H. www.timberpress.com)

This is the fully updated work by the late Perry Slocum, one of the most important breeders of aquatic plants. Nearly 500 species and cultivars are described and beautifully photographed. (The book includes species of the genera *Nymphaea, Nelumbo, Nuphar, Victoria, Euryale, Barclaya* and *Ondinea.*)

DECLARED PLANTS OF AUSTRALIA - An Identification and Information System, by S. Navie. 2004. CD.

(Published by the Centre for Biological Information Technology, University of Queensland, Brisbane 4072 AUSTRALIA. ISBN 186499785-0. AU$80.00 plus S/H. WWW: www.cbit.uq.edu.au/ software/declaredplants/default.htm)

This CD is easily used by your PC. Using the Lucid computer product, the ID system combines up to 35 characters to help you key out 300 noxious weeds ("declared plants") plus another 600 weed species in Australia. The plants are depicted in more than 5,000 color photos.

ICONOGRAFIA Y ESTUDIO DE PLANTAS ACUATICAS de la ciudad de Mexico y sus alrededores, by A. Lot and A. Novelo, Ilustraciones by E. Esparza. 2004. 206 pp.

(Published by Universidad Nacional Autonoma de Mexico, Instituto de Biologia, Ciudad Universitaria, 04510, Mexico, DF. ISBN 970-32-21319. Contact the authors: loth@servidor.unam.mx; lanovelo@servidor.unam.mx)

As Mary says, "This book is awesome!" Its large format includes beautiful full-page colored drawings of plants and plant parts, plus large-font descriptions in Spanish. Includes 10 emersed plants; 16 submersed plants; 6 floating-leaved plants; 10 floating plants.

BIOLOGICAL CONTROL OF INVASIVE PLANTS IN THE UNITED STATES, edited by E.M. Coombs, J.K. Clark, G.L. Piper and A.F. Cofrancesco, Jr. 2004. 467 pp.

(Published by Oregon State University Press, 102 Adams Hall, Corvallis, OR 97331;. ISBN 0-87071-029-X. WWW: http://oregonstate.edu/dept/press)

This is a very thorough review of previous and current bio-control projects in the US. The first 138 pages cover 16 topics under the general title of "The Theory and Practice of Biological Control". All steps and procedures are well-described in logical, straight-forward language: anyone who wants to understand, can understand.

The next 300 pages, "Target Plants and the Biological Control Agents", reviews all bio-control agents and experiences for more than two dozen aquatic, wetland and terrestrial plants, and include color photos of individual agents, and full descriptions of their biology, release and effect. The final 20 pages introduces new bio-control projects for 15 more major invasive plants of the US.

This book might be considered an essential reference for invasive plant workers world-wide.

The Aquatic Gardener

Some folks enjoy their aquatic plants, as opposed to those trying to manage uncontrolled growth of weedy species in large water bodies. For those lovers of water plants, there is the **Aquatic Gardeners Association, Inc., (AGA)** and their colorful journal, *The Aquatic Gardener*. Membership in AGA includes four issues per year. The stated purpose of AGA is to disseminate information about aquatic plants, to study and improve upon techniques for culturing aquatic and bog plants in aquariums and ponds, to increase interest in aquatic gardening, and to promote fellowship among members.

The Aquatic Gardener contains lots of information for the serious hobbyist and plenty of great photographs. The association is international in scope and includes an annual AGA International Aquascaping Contest. To find out more, visit their website at www.aquatic-gardeners.org

* **Perry Slocum leaves outstanding legacy.** By C.B. Thomas. 2004. *Water Garden Journal 19(4):15.*

"Water gardeners around the globe are mourning the passing of Perry Dean Slocum on November 29, 2004. At the same time, they are celebrating Perry's life and his outstanding legacy of achievement."

"[Perry] entered Cornell University with the idea of be-coming a medical doctor. However, well before he graduated in 1935, waterlilies had captured his imagination and soon became his life-long passion. He began growing them along with other ornamental aquatics as a teen. He gave up becoming a doctor so that he could grow and share his beloved aquatics....It became obvious that although he didn't become a doctor to the body, he became a doctor for the human spirit through his beloved *Nymphaeas, Nelumbos*, and other aquatics."

Mr. Slocum was a member of the Hall of Fame of the International Waterlily and Water Gardening Association.

* **The red waterlilies of Claude Monet - their origin and their venue to Giverny.** By M. Wallsten, J. Thorson and G. Werlemark. 2004. *Water Garden Journal 19:5-10*

Monet painted red waterlilies. Did he really see them? Where did they come from? Maybe from Lake Fagertarn in Sweden?

* **A rare feeding observation on water lilies (*Nymphaea alba*) by the capped langur *(Trachypithecus pileatus)*.** 2004. By A. Kumar and G.S. Solanki. *Journal of Raptor Research 75(3):157-159.*

The authors show pictures of a troop of monkeys in India wading in water and pulling up water lilies, all parts of which they then eat. Upon analysis, the lilies are shown to be 23% crude protein.

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AQUAPHYTE

AQUAPHYTE is the newsletter of the Center for Aquatic and Invasive Plants and the Aquatic, Wetland and Invasive Plant Information Retrieval System (**APIRS**) of the University of Florida Institute of Food and Agricultural Sciences (IFAS). Support for the information system is provided by the Florida Department of Environmental Protection, the U.S. Army Corps of Engineers Waterways Experiment Station Aquatic Plant Control Research Program (APCRP), the St. Johns River Water Management District and UF/IFAS.

EDITORS: Victor Ramey
Karen Brown

AQUAPHYTE is sent to managers, researchers and agencies in 71 countries around the world. Comments, announcements, news items and other information relevant to aquatic and invasive plant research are solicited.

Inclusion in **AQUAPHYTE** does not constitute endorsement, nor does exclusion represent criticism, of any item, organization, individual, or institution by the University of Florida.

A Q U A P H Y T E

A Newsletter about Aquatic, Wetland and Invasive Plants

Center for Aquatic and Invasive Plants
with support from
The Florida Department of Environmental Protection, Bureau of Invasive Plant Management
The St. Johns River Water Management District
Cerexagri

UNIVERSITY OF FLORIDA
IFAS EXTENSION

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In the Classroom & In the Parks

A Teaching Package About Non-Native Invasive Plants For Florida's Science Teachers and Park Biologists

For the first time, Florida's school students will be formally introduced to two subjects dear to our hearts: aquatic plants and invasive plants. Educational materials are being developed for teachers and students.

By the fall of 2006, based on what teachers will learn during in-service training conferences, we expect 800 science teachers to begin teaching these subjects to nearly 100,000 K-12 students per year. New Study Units, Lesson Plans, Labs and Activities will meet Florida's curricula requirements as defined in the "Sunshine State Standards and Benchmarks" and will be able to be folded into subject areas as diverse as environmental science, mathematics and even English composition.

A second focus of the initiative is workers in the state's 153 public parks and wild lands. Plant identification training is being offered to park biologists, rangers and lead volunteers; and educational materials, including regionalized plant identification foldouts and other printed resources, are being created and printed for specific parks and regions.

These two programs are part of Florida's Invasive Plant Education Initiative, an effort of the Center for Aquatic and Invasive Plants (IFAS, University of Florida) and the Bureau of Invasive Plant Management (Florida Department of Environmental Protection). Vic Ramey (UF/IFAS) and Jeff Schardt (FDEP) are co-authors of the Initiative.

Using the expertise and source materials of UF/IFAS and FDEP, two award-winning curricula-writing teachers, Elaine Taylor and Cynthia Holland of the Alachua County School District (Florida), are authoring the teaching units, plans, labs and activities.

Publications experts Amy Richard and Emily Cunningham are producing printed educational materials such as plant ID guides to be given free to teachers, students, biologists, rangers, volunteers and tourists.

Web specialist Beth DeGroat is preparing the Initiative's web sites, which will feature interactive modules such as plant-knowledge card games; online coloring; crossword puzzles, prizes; etc.

All products of the Initiative are based on research found in the **APIRS** science library and online database; **APIRS** is the UF/IFAS collection of more than 65,000 science reports and books about aquatic plants and invasive plants. The **APIRS** collection is managed by Karen Brown, with cataloger Mary Langeland, and library specialists, Karen Marshall and Beth Noll.

This is the first year of Florida's Invasive Plant Education Initiative. With its success, we hope to continue the Initiative until every science teacher, every student, and every park biologist, ranger and docent volunteer are knowledgeable of the invasive plants in their areas, and have the resource materials necessary to help them identify, contain, control and prevent plant invasions in the natural areas of the Sunshine State.

Nearly 200 non-native plant species are invading Florida's atural areas, and more are being introduced. The trend won't be reversed until teachers and students, and park workers and visitors, know the issues, know the plants, and know what they can do to help save our wetlands and uplands.

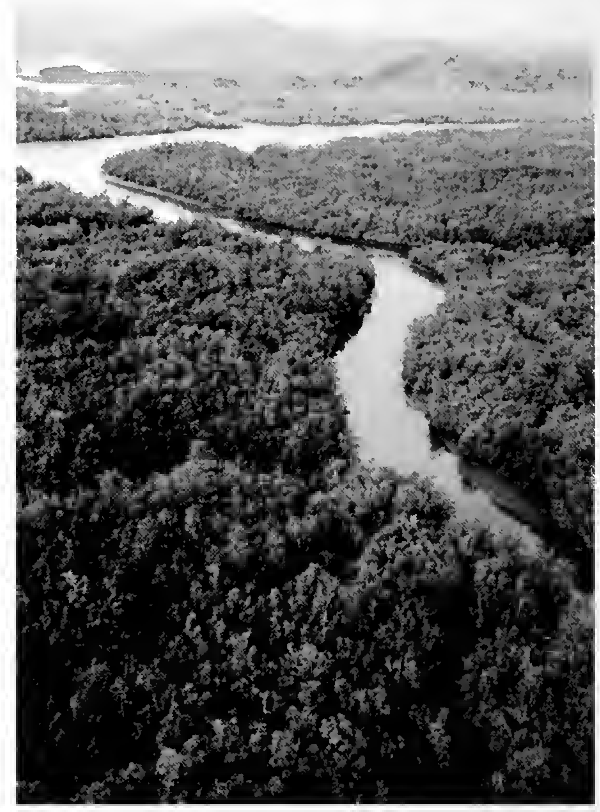
VR

The Wetlands of Turuepano National Park, Orinoco Delta, Venezuela

by Giuseppe Colonnello, Museo de Historia Natural La Salle, Caracas
trans. Chet Van Duzer

The wetlands of Turuepano National Park are a landscape of exceptional beauty and are a part of the extensive strip of mangroves that flank the northeastern coast of South America. The area is characterized by heterogeneous plant communities and is the habitat for a various and colorful bird population as well as for reptiles and mammals in danger of extinction, among them the manatee; it also contains valuable fish resources. The park is framed by courses of water that begin as small streams among mangrove roots and become channels of hundreds of meters of wide in which tunas and occasionally dolphins may be observed. All of these factors make the park an ideal setting for nature tourism, environmental studies, and conservation.

Turuepano National Park is in the deltaic system of the Orinoco River, which is in the northeastern coastal plains of Venezuela. These plains stretch from the Gulf of Paria in the north to the river San Juan in the south and occupy 508,886 ha. The delta is principally drained by the tidal channels named *Ajies, Turuepano, Guariquen*, and *La Palma*. The topography of the land in the park is similar to that elsewhere in the delta: the banks of the tidal channels are elevated and behind these banks the land is lower, so that islands in the delta have a characteristic bowl shape.



The vegetative communities of Turuepano National Park are largely determined by local geomorphology and topography. In higher areas which are not susceptible to flooding and which generally have mineral soils we see tall woody vegetation, while in the lower areas which are often flooded and whose soils are largely organic (at least on the surface), a herbaceous vegetation is typical. There is significant intrusion of salt water from the Gulf of Paria up the tidal channels of the delta, and this saline intrusion results in the colonization of halophytic vegetation along these channels almost to their sources in the delta. Thus mangroves of the genera *Rhizophora, Avicennia* and *Laguncularia* are common along these banks and occupy wide strips along the coast, for example around Turuepano Island; their density decreases higher in the tidal channels. Accompanying the mangroves are salt-tolerant herbaceous species such as the fern *Acrostichium aureum* and the reed *Rabdadenia biflora*. The salinity of the soil diminishes precipitously with any distance from the water, and thus non-halophytic species thrive in the interiors of the islands .

In areas where the salinity of the soil is low there are communities dominated by palms such as *Roystonea oleracea, Euterpe oleracea* y *Bactris*, and *Tabebuia rosea*. The giant arum *Montrichardia arborescens* grows in brush lands; this plant generally grows to be 2 or 3 meters high, but in certain conditions, for example in areas that have recently burned, it can reach a height of 6 or 7 meters. In these environments the water generally has a salinity of 3.4 PPT, a conductivity of 6210 (μS/cm), and a pH of 6.5.

In levees where the influence of the sea is stronger, the vegetation on the banks of the channels is a mangrove swamp with trees 15 to 20 meters high, in two strata. The swamp consists of a combination *Rhizophora mangle, R. harrisonii, R. racemosa, Avicennia germinans* and *Laguncularia racemosa*, with the liliaceous plant *Crinum erubescens* growing in the lower strata. In the interior depressions of the islands there is a dense, permanently inundated shrubby swamp with plants 2 to 3 meters high. This community consists of woody and herbaceous species dominated by dogbane *(Rabdadenia biflora)* and the pteridophyte *Acrostichium aureum*, in addition to *Odontodenia* sp., *Heteropterys orinocensis* with yellow flowers and the palm *Bactris* sp. Fires may change these communities so that they are dominated by Cyperaceae. In the lower areas grow the liliaceous plant *Crinum erubescens*. In these swamps the water has a salinity of 11.8 PPT, a conductivity of 19850 (μS/cm), and a pH of 6.3. However, in some areas closest to the Gulf of Paria the high salinity of certain lagoons creates communities of dwarf mangrove stands, 1 to 3 m tall.

Another type of woody plant community is a swamp forest of medium height (15 m) and density, with two strata. The dominant species are *Symphonia globulifera* and *Cassipoura guianensis*, which grow in levees with a clayey-muddy soil and an organic surface on the island of Turuepano. The second stratum grows to 8 or 10 meters and is dominated by *Euterpe precatoria, Rhizophora harrisonii* and *Ficus* sp. As one moves towards the interior of the island the forest turns into a shrubby swamp growing to 3-5 meters, and then one sees a dense herbaceous swamp dense with the fern *Blechnum serrulatum*. This fern is able to withstand the frequent fires that affect these communities because it has a subterranean rhizome. As the fire removes the trees and palms they are replaced by these ferns. This community grows about 1.5-2 meters high and contains few (8-10) species, among which the fern achieves coverage of 70-80%. Other species in this community include *Rhynchospora gigantea* and *Ludwigia nervosa*. The soil is organic and the water is completely fresh: the salinity is 0.1 PPT, the conductivity 281.6 (μS/cm), and the pH 4.3.

In the northern part of the park there are extensive grasslands with *Eleocharis interstincta, Eleocharis mutata* and shrubs growing on mineral soils. The species that compose this community are much more numerous, with a total of about 22; the plants grow in a mosaic of dense colonies on a matrix of *Eleocharis* ssp. The shrubby species here, such as *Sesbania emerus, Machaerium lunatum* and *Thalia geniculata*, form stands of one or a few species which stand out from their surroundings because of their greater height and distinct appearance.

The growth of aquatic plants in the tidal channels is limited by the salinity of the water. In the upper reaches of the Ajíes channel it is possible to find aquatic macrophytes growing along the banks. The most common are *Echynochloa piramidatus, Panicum grande, Hymenachne amplexicaulis, Panicum mertensii* and *Paspalum maximum*, in addition to the lianas *Odontodenia* sp., *Paullinia pinnata* and *Cydista aequinoctialis.* Among the free-floating species, one sees *Eichhornia crassipes* which forms large communities at the heads of the channels, and also two species with roots fixed in the bottom and floating leaves, namely *Nymphaea rudgeana* in some pools and *Eichhornia heterosperma* in the middle of the current. We also found one species, *Ceratophyllum submersum,* growing submerged below 40 cm of water. In this sector the salinity is 0.3 PPT, the conductivity 632 (μS/cm), and the pH 7.1.

In this habitat it is possible to find communities with extensive populations of free-floating species (*Lemna perspusilla*); floating-leaf species (*Nymphaea* sp.); emergent species that are low in the water (*Sphenoclea zeylanica, Luziola subintegra* and *Leersia hexandra)*; rooted species that rise well out of the water (*M. arborescens, Thalia geniculata*, and *Cyperus giganteum*); and climbing species *(Mikania congesta).* One uncommon species that is present in this community is *Hymenocallys venezuelensis.* In other parts of this area there are populations of *T. geniculata* and *C. giganteus* that measure 1-2 ha.

Turuepano National Park is subject to various environmental threats. The most significant of these is the poverty of the local people, who are obliged to live off the natural resources of the wetlands and to farm within the limits of the Park, planting taro (*Colocassia esculenta*) in the flooded areas and plantains (*Musa* spp.) and cassava (*Manihot* spp.) in the dry areas. In addition, the harvesting of oysters and mussels as well as mangrove wood has increased. The people engaged in these activities sometimes start fires, as do the poachers who kill deer, peccaries and other species; these fires reduce the coverage of forests and shrubs and thus allow *Blechnum serrulatum* to spread excessively. The rate of deforestation has increased dramatically in the last 20 years, as is immediately evident from examination of historical aerial photographs. The main damage is the reduction of palm communities (*Mauritia flexuosa*), which were once extensively distributed in the lower-elevation areas of the park and of its surroundings. One possible way to manage the area would be to assess the wetlands and their resources, involving the local people in the management scheme, and to create "buffer zones" in the periphery of the park where controlled subsistence farming would be permitted, while strictly prohibiting all such activities in the central part of the park and enforcing these rules with enough personnel of the Venezuelan National Park Agency.

Mary's Picks!

Items throughout this issue marked with "" are from articles that particularly piqued the interest of Mary Langeland, the reader/cataloger for the* ***APIRS*** *database.*

* **What makes a weed a weed: life history traits of native and exotic plants in the USA.** 2004. By S. Sutherland. *Oecologia 141(1):24-39.*

The author compared ten life history traits for the 19,960 plant species that occur in the USA. He found that a) life span was the most significant life history trait for weeds - weeds were more likely to be annuals and biennials than perennials; b) weeds were more likely to be wetland adapted, toxic and shade intolerant; and c) weeds were more likely to be monoecious and trees.

* **Creation of *Spartina* plantations for reclaiming Dongtai, China, tidal flats and offshore sands.** By C.H. Chung, R.Z. Zhuo, G.W. Xu. 2004. *Ecological Engineering 23(3):135-150.*

China wanted to reclaim lost salt marshes. Through "ecological engineering" and "skillfully using *Spartina alterniflora* plantations," they are protecting their coastal areas by damping waves, reducing current velocity and accreting sediments.

* **A review of the occurrence of halophytes in the eastern Great Lakes region.** By P.M. Catling and S.M. McKay. 1981. *The Michigan Botanist 20: 167-180.*

Salt-tolerant plants don't occur just on the sea shore: inland salt springs and other sodium-rich habitats may occur far inland, along with plants usually associated with oceanic coastlines.

More of *Mary's pics* ~

* **Factors affecting the Agrobacterium-mediated transient transformation of the wetland monocot, *Typha latifolia.*** 2004. By R. Nandakumar, L. Chen and S.M.D. Rogers. *Plant Cell, Tissue and Organ Culture 79:31-38.*

This is about how to genetically transform cat-tail, a plant already useful for heavy metal decontamination, so that it can be made even more useful.

* **A fern that hyperaccumulates arsenic.** 2001. By L.Q. Ma, K.M. Komar, C. Tu, W. Zhang, Y. Cai, and E.D. Kennelley. *Nature 409:579.*

A non-native fern in Florida, *Pteris vittata* (Chinese ladder brake), was discovered growing in a site highly contaminated with chromated copper arsenate. It was found to take up a number of species of arsenic to concentrations as high as 22,000 ppm. The authors believe this to be the first known arsenic hyperaccumulator as well as the first fern found to function as a hyperaccumulator, a plant that could be used in arsenic remediation programs to restore contaminated sites.

* **Brahmi (*Bacopa monnieri* (L.) Pennell) - A Medhya Rasaayana drug of Ayurveda.** 2004. By M Rajani, N Shrivastava and MN Ravishankara. In *Biotechnology of Medicinal Plants: Vitalizer and Therapeutic, ed by K.G. Ramawat, Science Publishers Inc., Enfield, NH, 302 pp; pgs 89-110.*

This aquatic plant, apparently good for whatever ails ya, placed second on a priority list of the most important medicinal plants in India.

* **Extensive hydrochory uncouples spatiotemporal patterns of seedfall and seedling recruitment in a "bird-dispersed" riparian tree.** 2004. By A. Hampe. *J. Ecology 92(5):797-807.*

Seed dispersal and seedling abundance of the endangered Spanish tree, *Frangula alnus*, is discussed. "Even complex, multistep dispersal systems may produce remarkably consistent year-to-year distributions of recruits . . . ."

* **Nests and nest habitats of the invasive catfish *Hoplosternum littorale* in Lake Tohopekaliga, Florida: a novel association with non-native *Hydrilla verticillata.*** By L.G. Nico and A.M Muench. 2004. *Southeastern Naturalist 3(3):451-466.*

In Florida, an invasive catfish from South America is using an invasive plant from Asia to construct its large dome-shaped nests.

* **The effect of sex steroids and corticosteroids on the content of soluble proteins, nucleic acids and reducing sugars in *Wolffia arrhiza* (L.) Wimm. (Lemnaceae).** 2004. By I.K. Szamrej and R. Czerpak. *Polish J. Environmental Studies 13(5):565-571.*

Because *Wolffia* is able to use testosterone, cortisone and other organic substances as energy and carbon sources, the authors suggest the plant can be used in sewage treatment in small urban and rural environments.

* **Personal view - Seeds, seed banks and wetlands.** By M.A. Leck. 2004. *Seed Science Research 14:259-266.*

A nicely written reminiscence about how a researcher is a teacher.

* **Forensic palynology and ethnobotany of *Salicornia* species (Chenopodiaceae) in northwest Canada and Alaska.** 2005. By P.J. Mudie, S. Greer, J. Brakel, et al. *Can. J. Bot. 83:111-123.*

Kwaday Dan Ts'inchi (Long Ago Person Found) died on a British Columbia glacier 550 years ago. A team of researchers studied Chenopodiaceae pollen found in his stomach and robe using scanning electron microscopy (SEM). The stomach sample contained pollen grains from *Salicornia* (Tourn.) L. (glasswort), a succulent perennial salt marsh species, most likely *Salicornia perennis*.

* **Conservation team reveals 'floating' islands.** 2005. By J.L. Bartak. *Oryx 39(2):126.*

Members of a research and conservation initiative in Argentina found that marsh islands in the Parana River Delta float when the water level of the wetlands rise, providing shelter to resident marsh deer populations. The islands moved vertically carrying vegetation, 3-m trees and, in one high-level event, more than 30 deer.

* **Biogeography of discontinuously distributed hydrophytes: a molecular appraisal of intercontinental disjunctions.** By D.H. Les, D.J. Crawford, R.T. Kimbsall, M.L. Moody and E. Landolt. 2003. *Internat'l. J. Plant Sciences 164(6):917-932.*

Darwin noted in 1859 that many freshwater flowering plants have "enormous ranges." Why? Birds carry their seeds? Continental drift? The authors suggest that birds really might be the answer.

* **Wetlands of Central America.** By A.M. Ellison. 2004. *Wetlands Ecology and Management 12:3-55.*

This is a review of the literature about the 40,000 square kilometers of wetlands of Belize, Guatemala, Honduras, El Salvador, Nicaragua, Costa Rica and Panama. The five wetland types discussed are marine, estuarine, riverine, lacustrine and palustrine.

* **Alien aquatic plants naturalized in Japan: History and present status.** By Y. Kadono. 2004. *Global Environmental Research 8(2):163-169.*

The need for education and legal regulation is emphasized as the professor discusses over 40 species that have escaped and become naturalized in Japan.

* **Constraints in range predictions of invasive plant species due to non-equilibrium distribution patterns: purple loosestrife *(Lythrum salicaria)* in North America.** By E. Welk. 2004. *Ecological Modelling 179(4):551-567.*

What are some of the limitations of the models used to predict distribution patterns of plants outside their native range? Would incorporating "native range distribution" data into the models make a difference?

* **Introducing aquatic palms.** By J. Monteverde. 2005. *Water Garden Journal 20(1):5-11.*

This interesting article contains a list of 130 species of palms that like wet feet.

* **Reviving Iraq's wetlands.** By A. Lawler. 2004. *Science 307(5713):1186-1189.*

So as to better make war with each other, Iran and Iraq drained the ancient marsh lands that once divided their two countries. Most of the thousands of square kilometers of marsh were turned to deserts. Can they restore the Garden of Eden?

BOOKS/REPORTS

FLORIDA ETHNOBOTANY, by D.F. Austin. 2004. 909 pp.

(Published by CRC Press, 2000 NW Corporate Blvd, Boca Raton, FL 33431. ISBN 0-8493-2332-0. $149.95 plus S/H. 1-800-272-7737. WWW: http://www.crcpress.com)

This huge compilation of the literature discusses the uses of nearly 900 plant species by the native peoples of Florida. In it, for example, we learn that "*Juncus*" comes from Latin "*iuncus*," meaning to tie or bind, which is what they used to do with these flexible-stemmed, tough-leaved rushes. What's more, we learn that the pith of *Juncus*, "when dried and oiled, will serve as a wick."

FEDERAL NOXIOUS WEED DISSEMINULES OF THE U.S. - An interactive identification tool for seeds and fruits of plants on the United States Federal Noxious Weed List, by J. Scher. 2005. Compact Disk.

(Published by the USDA Center for Plant Health Science and Technology, CDFA Plant Pest Diagnostics Center, 3294 Meadowview Road, Sacramento, CA 95832; (916) 262-3181. Email: julia.l.scher@aphis.usda.gov)

The title says it all: an information guide to the plant propagative units of 105 invasive or potentilly invasive plant taxa on the US "federal noxious weed list." It includes lots of pictures (about 700), fact sheets, botanical descriptions, ID tips, and distribution.

An unequalled resource, for those who need it.

OUT OF EDEN - AN ODYSSEY OF ECOLOGICAL INVASION, by A. Burdick. 2005. 325 pp.

(Published by Farrar, Straus and Giroux, 19 Union Square West, New York, 10003; (212) 741-6900. ISBN 0-374-21973-7.)

Another in the recent cascade of "invasives" books, this one updates us on the most recent insights and codewords of invasions experts: we're now in the "Homogecene," where the "homogenization of the world" is resulting in a "creeping sameness" which threatens to render all our home territories indistinguishable from one another. Is this true, really?

The book is an ironically aware 300-page report/philosophical tract about the "ineffability" of the problem: "Do ecological communities that formed over a geological timespan differ in some fashion - in productivity, in potential stability - from those that were tossed together last month, last year, last century? Do recombinant communities differ from "normal" ones? Does time matter?"

As the author points out, ". . . humans have yet to devise a technique for making concerted measurements of ecological communities over time periods longer than the average human life span." So what do we really know about eco-invasions and their long term effects? What policies can we adopt when we don't know the answers to basic questions?

Oddly, there's no table of contents, nor an index.

THE ROLE OF DISPERSAL, PROPAGULE BANKS AND ABIOTIC CONDITIONS IN THE ESTABLISHMENT OF AQUATIC VEGETATION, by G. Boedeltje. 2005. 224 pp.

(Ph.D. Thesis. In English. Aquatic Ecology and Environmental Biology, Department of Ecology, Radboud Universiteit, Nijmegen, The Netherlands. ISBN 90-9019528-9. Email: g.boedeltje@science.ru.nl)

This book includes seven journal papers that are based on Ph.D. research in The Netherlands, and includes a "Synthesis." The author determined that certain plant species are dispersed by generative and vegetative diaspores; that water flow pulses significantly affect plant dispersal in stream and river systems; that plant diversity is unlikely in newly created backwaters; and that certain plant species provide for invertebrate diversity.

ISSUES IN BIOINVASION SCIENCE, EEI 2003: A Contribution to the Knowledge on Invasive Alien Species, edited by L. Capdevila-Arguelles and B. Zilletti. 2005. 147 pp.

(Reprinted from *Biological Invasions, Volume 7, No. 1, 2005.* Published by Springer, 101 Philip Drive, Norwell, MA 02061. ISBN 1-4020-2902-0.)

This book is a collection of 14 papers from *Biological Invasions.* Research topics include invasive fungi, weeds, shrimp, crayfish, mosquitoes, fish, rodents and other animals.

DOCUMENTATION, CHARACTERIZATION, AND PROPOSED MECHANISM OF DIQUAT RESISTANCE IN *LANDOLTIA PUNCTATA* (G. MEYER) D.H. LES AND D.J. CRAWFORD, by T.J. Koschnick. 2005. 110 pp.

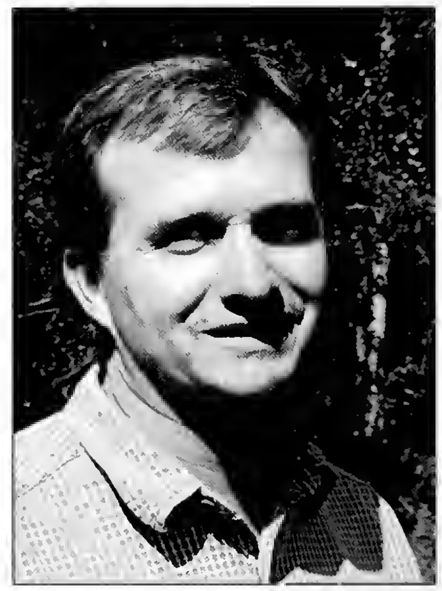
(Ph. D. Thesis. Agronomy Department, University of Florida, Gainesville. Email: tjkoschnick@ifas.ufl.edu)

These studies documented the first aquatic plant to become resistant to the bipyridylium herbicides, and suggest that the resistance mechanism is related to reduced herbicide transport across cell membranes.

Hydrocharis morsus-ranae
European frog-bit

Aquatic Herbicide Resistance in Hydrilla

- a review by Karen Brown



The world of aquatic plant managers in Florida was rocked when the number one submersed aquatic weed in the state, *Hydrilla verticillata*, began showing signs of resistance to fluridone, the only EPA-approved systemic herbicide for large-scale hydrilla control. Research biologist **Dr. Michael Netherland** (pictured) worked for the manufacturer of fluridone at the time of this discovery. He has since returned to a research position with the U.S. Army Engineer Research and Development Center, and is stationed at the University of Florida IFAS Center for Aquatic and Invasive Plants.

Hydrilla (Hydrocharitaceae; *Hydrilla verticillata* (L.f.) Royle) is one of the worst exotic aquatic weeds in the southern United States, with millions of dollars spent annually to control large infestations in all types of water bodies. The most successful aquatic herbicide to date has been fluridone, sold under the tradename of Sonar. Within the last several years, however, at least three hydrilla biotypes have been discovered with a two- to six-fold higher resistance to fluridone than the wild type. The discovery of this herbicide resistance was a shock to aquatic plant managers, researchers, and herbicide manufacturers alike, as it jeopardizes the ability to manage hydrilla in a cost-effective and selective manner.

Hydrilla occurs around the world with reports from Europe, Asia, Africa, Australia and the Americas. Accessions from Florida, Texas and California are believed to have one common origin close to Bangalore, India. Hydrilla was introduced to Florida from Asia in the late 1950s, probably as an aquarium plant, and first recorded in a Florida lake in 1959. By the 1970s, it had spread throughout Florida water bodies, and by the 1990s, it infested approximately 140,000 acres in 288 water bodies of Florida. Hydrilla hampers flood control by filling drainage canals, rivers and lakes; it restricts navigation, clogs irrigation systems and water control structures in reservoirs and other impoundments, and impacts the recreational use of water bodies. It also affects nutrient cycles, water quality, and fish and other aquatic animal populations. It threatens even human safety by entangling swimmers, and deaths have been reported.

> ***"While resistance development makes sense in hindsight, it was unexpected that a vegetative plant would develop somatic mutations that would confer resistance to fluridone."***

Hydrilla has low light and CO^2 compensation points and a low light saturation point, enabling it to grow in only 1% of full sunlight. This competitive advantage, in addition to the ability to shift between C3 and C4-type photosynthesis depending on the environment, enables hydrilla to combat adverse conditions such as high temperature and irradiance, high oxygen concentration and limiting carbon dioxide. Dioecious hydrilla (male and female flowers occur only on separate plants) in Florida can grow from the substrate to the water surface and reach up to 15m in length. It "tops out" to form thick, impenetrable mats. Root crowns in the sediment develop horizontal above-ground shoots that form new plants. Stems branch out with leaf whorls at the nodes, each of which can regenerate to a new plant. However, the primary reproductive method is by turions that form in the leaf axils (axillary turions) and at the end of rhizomes in the substrate (subterranean turions). Subterranean turions can remain viable in the substrate for as long as 5 years. Approximately 2,000 to 3,000 turions per m^2 have been recorded in Florida lake sediments within a four month period, and almost 3,000 turions per m^2 (millions/acre) were recorded during a single winter season. Axillary turions are smaller and generally form on floating mats of hydrilla that have broken off from the parent plant, allowing for dispersal of a population. Axillary turions remain viable for approximately one year once they drop off and fall to the substrate.

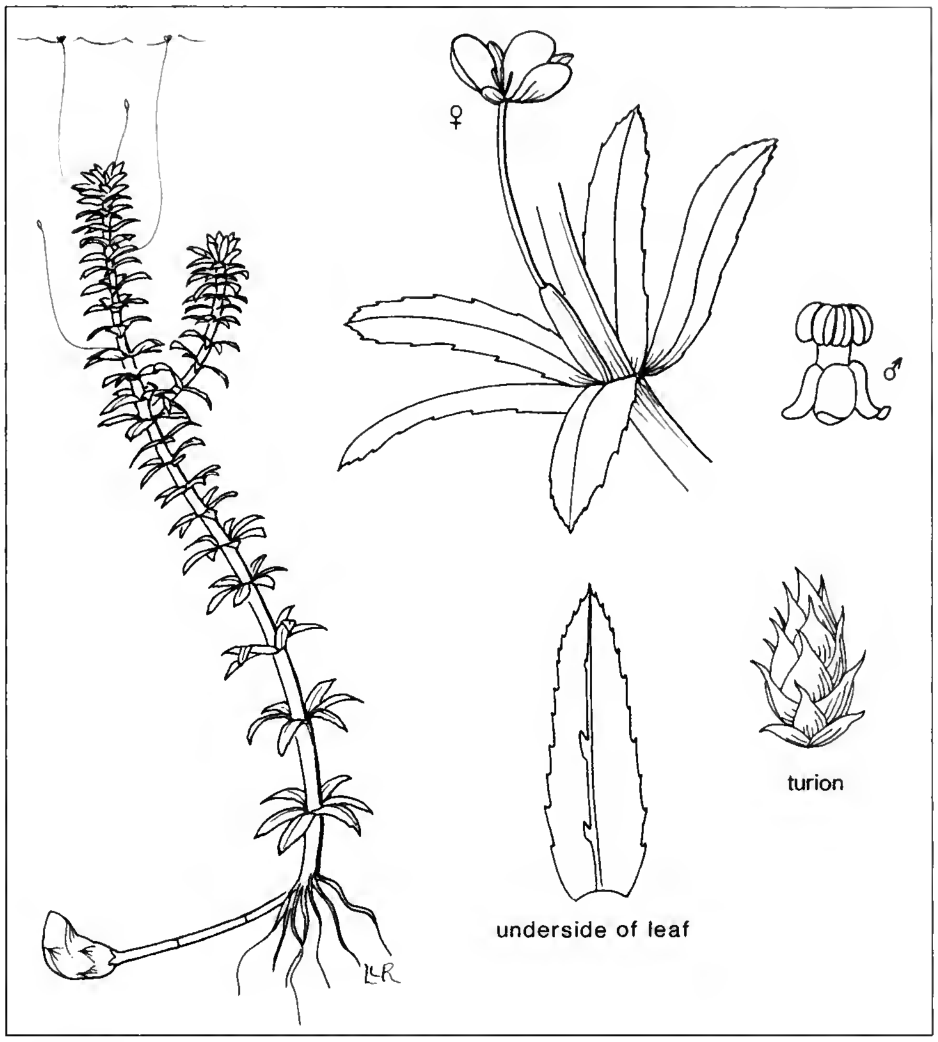
Hydrilla Control

Many methods of hydrilla control have been investigated, including mechanical, biological and chemical means. Drawdowns, fungal pathogens, introduced insects, large dredging machines and more have been used to attempt to control the explosive growth of the weed. Contact herbicides (endothall, diquat, and chelated copper) have been used to control hydrilla since the mid-1960s. Typically they are used for smaller or new infestations, while the systemic herbicide fluridone is used for large-scale control. Fluridone is the only cost-effective systemic aquatic herbicide for the large systems typically found in Florida. It has been approved by the US Environmental Protection Agency for aquatic systems since 1986. In fiscal year 2003-2004, more than $15 million was spent managing hydrilla in more than 27,000 acres of Florida's public water bodies. Many treatments in 2005 were suspended due to issues with high water flow, inability to maintain the desired treatment concentrations, and lack of phytotoxic impact on hydrilla.

Hydrilla Resistance to Herbicides

"Factors likely to accelerate the selection of resistant biotypes are the repeated use of the herbicide in large areas, no use of alternative mode of action herbicides, high efficacy of the herbicide on the sensitive biotype at the rate used, and residual herbicide activity." Due to the lack of alternative compounds that could be used for large-scale control efforts and the nature of the fluridone molecule, this is exactly how fluridone is used to control hydrilla. Weed management with fluridone is accomplished by maintaining a constant herbicide concentration in lakes over several weeks to months.

Hydrilla had been susceptible to very low concentrations of fluridone.The first signs of fluridone resistance were in 1999. Major sampling efforts were conducted in 2001-2002. Studies revealed that hydrilla phenotypes with two- to six-fold higher fluridone resistance were present in several water bodies. The mutations were directly related to fluridone resistance and researchers concluded that they were the result of any one of three independent somatic mutations at the molecular target site of fluridone. Fluridone is an enzyme inhibitor, and the molecular target site is phytoene desaturase (PDS), one of the key enzymes in carotenoid biosynthesis. In the absence of protective carotenoids, photobleaching of newly emerging green tissue results. Hydrilla may be particularly susceptible to mutations caused by ultraviolet light because a hydrilla leaf blade is only two cell-layers thick. Treatments with fluridone are more effective toward the surface (high light intensities) than in deeper water (low light intensities). This type of selection predicts that if a mutation provides an adaptive advantage to the plants regenerated from the mutated cell, the trait can rapidly spread through the population. This could be the case of the resistant biotypes observed in Florida lakes. In hydrilla, somatic mutations transmitted in either the apical or any of the numerous axillary meristems do not necessarily die with the rest of the plant, as would be typical in terrestrial systems, but fragments of hydrilla possessing a meristem can regenerate into entire plants. Hydrilla is a polyploid plant (chromosome counts vary widely within a vegetative population). Researchers suggest that the variable ploidy of hydrilla could contribute to its adaptation and rapid development of herbicide resistance. These scenarios may have enabled the resistant hydrilla biotypes to become the dominant populations within each lake.



Hydrilla verticillata

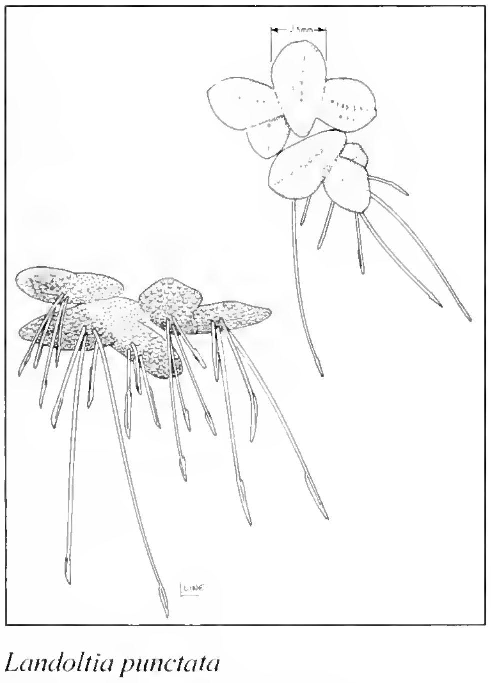
For a more in-depth publication on this topic, see *Somatic mutation-mediated evolution of herbicide resistance in the nonindigenous invasive plant hydrilla* (Hydrilla verticillata), 2004, A. Michel, R.S. Areas, B.E. Scheffler, S.O. Duke, M. Netherland, F.E. Dayan, *Molecular Ecology 13:3229-3237.* Contact Michael Netherland at: *MDNether@ifas.ufl.edu*

Much more information on *Hydrilla verticillata* can be found on the **APIRS** web site at: *http://plants.ifas.ufl.edu/seagrant/hydver2.html*

An in-depth review of hydrilla management options, and the issue of fluridone resistance, can be found as a PDF document, *Hydrilla Issues Workshop*, Final Report, Gainesville, FL, December 2004, at: *http://lakewatch.ifas.ufl.edu*

More information on herbicide resistance in plants may be found from the International Survey of Herbicide Resistant Weeds: *http://www.weedscience.org/in.asp*

Aquatic Herbicide Resistance in Landoltia



Landoltia punctata

Dr. Tyler Koschnick recently received his Ph. D. through the Agronomy Department here at the University of Florida. He currently is a visiting assistant professor at the Center for Aquatic and Invasive Plants and is continuing his research into the resistance of *Landoltia punctata* to the aquatic herbicide, diquat.

Trials conducted with *Landoltia punctata* (G. Meyer) D.H. Les and D.J. Crawford collected from a canal in Lake County, Florida showed a 50-fold resistance to diquat, and a cross resistance to paraquat. The resistance was independent of photosynthesis and the response to the diquat was delayed compared to a non-resistant biotype. It is presumed that less diquat was transported into the protoplast. Copper applied in combination with diquat overcame the resistance. It is thought that copper may alter the transport mechanism for diquat across the plasmalemma or open a secondary site for transport. These relationships warrant further study relating to diquat transport and potential resistance mechanisms.

These studies document the first aquatic plant to develop resistance to the bipyridylium herbicides.

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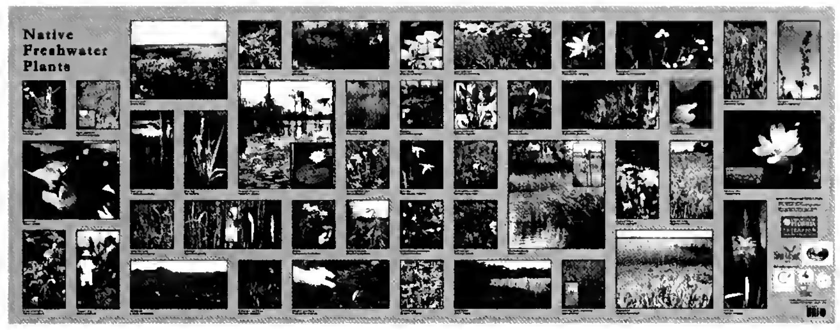
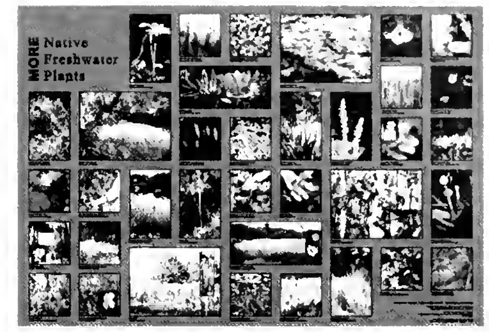


Native Freshwater Plants 23" X 60"



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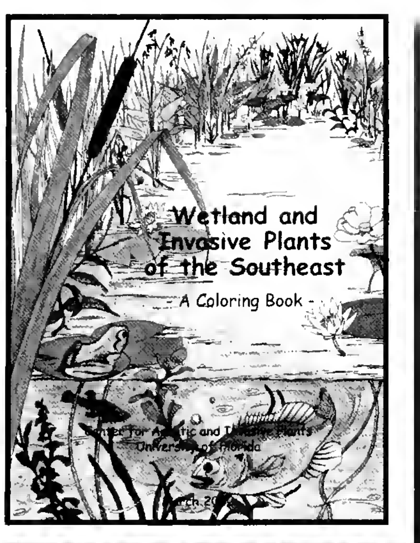

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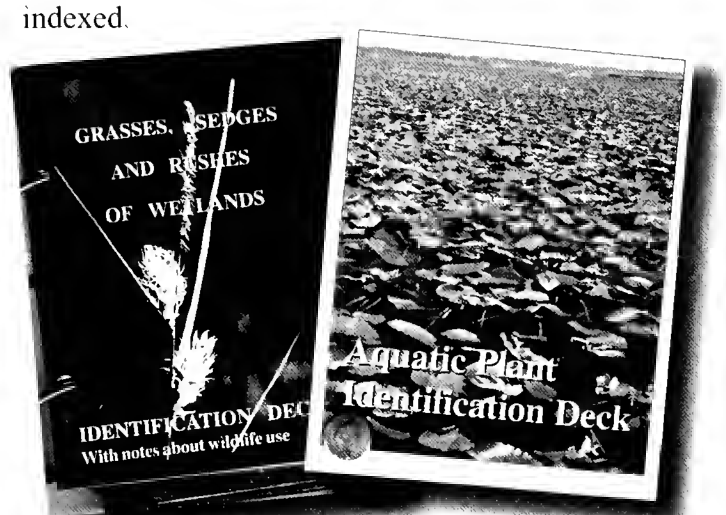

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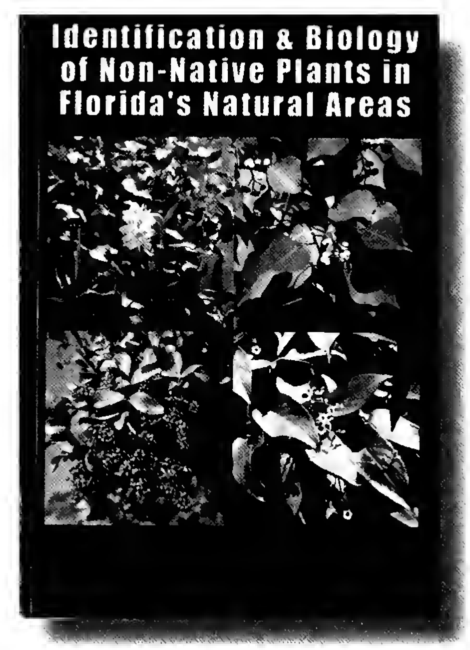

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FROM THE DATABASE

Here is a sampling of the research articles, books and reports which have been entered into the aquatic, wetland and invasive plant database since Spring 2005. The APIRS database contains more than 66,000 citations. To use the free database online, go to http://plants.ifas.ufl.edu/ and click on APIRS Online Database.

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Ecological models for aquatic plant growth

by EPH Best, U.S. Army Engineer Research & Development Center, Environmental Laboratory

Ecological response models for submersed aquatic plants have been developed at the US Army Engineer Research & Development Center, Environmental Laboratory during the last decade. All models are based on the carbon flow through the plant and simulate the response of submersed aquatic vegetation to changes in water level, temperature, water transparency, and biomass-removing activities (such as mechanical control and grazing) at sites differing in climate.

Two models pertain to invasive aquatic species, i.e. hydrilla *(Hydrilla verticillata)* and Eurasian watermilfoil *(Myriophyllum spicatum)*, and two models pertain to desired aquatic species, i.e. American wildcelery *(Vallisneria americana)* and sago pondweed *(Potamogeton pectinatus)*. The models are named: HYDRIL, MILFO, VALLA, and POTAM. Of the four monotypic models, stand-alone versions 1.0 are available and can be downloaded as executable files at no cost from: *http://el.erdc.usace.army.mil/products.cfm?Topic=model&Type=aquatic* The models have been described in technical reports and operation is explained in user manuals, both available at the same website. Currently more than 140 models per year are being downloaded.

The two monotypic models VALLA and POTAM have been recalibrated and expanded with responses to current velocity and epiphyte shading for use at the Upper Mississippi River System (Pool 8). Upgraded stand-alone versions 2.0 are being prepared. These models have also been translated in Visual Basic, and are currently considered for inclusion in a Decision Support System under discussion for application to the Upper Mississippi System (Pool 5). Pools, short for 'navigation pools,' are permanently inundated impounded areas above navigation dams (and locks) in rivers.

A competition model describes the behavior of two species competing for the most limiting resource, light, at high and low N and P availabilities. The species concerned are the meadow-forming American wildcelery and the canopy-forming sago pondweed. This model will become available for users shortly.

The models can be used to predict habitat suitability, species-characteristic plant response and, in the case of the competition model, outcomes of competition at variable N and P availabilities at sites differing in climate, water level, water transparency, current velocity, epiphyte shading, and biomass-removing activities. Preferred sites are lakes, reservoirs, and rivers (including pools).

All of these models can be modified to operate with hydrodynamic, physical, and chemical models such as the US Army Corps of Engineers uses to predict environmental alterations caused by dredging, water elevation manipulation, altered temperature, altered flow, altered sediment transport, altered nutrient levels, and altered habitat. In fact, one model, i.e., VALLA, has served already as a test case for integration with a hydrodynamic (RMA2) and sediment transport (SED2D) model. Publications pertaining to these models may be obtained from the author.

For more information and a list of related publications, contact Dr. Elly P.H. Best, Leader Plant Processes & Effects Team, Environmental Laboratory, CEERD-EP-R, U.S. Army Engineer Research & Development Center, 3909 Halls Ferry Road, Vicksburg, MS 39180-6199, USA; 601-634-4246; email: beste@wes.army.mil

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MEETINGS

Weed Science Society of America (WSSA), Annual Meeting, February 13-17, 2006, New York, NY. www.wssa.net

National Invasive Weeds Awareness Week (NIWAW), February 26 - March 3, 2006, Washington, DC. www.nawma.org/niwaw

North American Lakes Management Society (NALMS), and **Georgia Lakes Society,** March 8-10, 2006, Columbus, GA. www.nalms.org -or- georgialakes.org

Association of Southeastern Biologists (ASB), Annual Meeting, March 29 - April 1, 2006, Gatlinburg, TN. www.asb.appstate.edu/

Florida Vegetation Management Association, Annual Meeting, April 19-21, 2006, Daytona Beach, FL.

Florida Exotic Pest Plant Council (FLEPPC), Annual Meeting, April 24-26, 2006, Gainesville, FL. www.fleppc.org

UF-IFAS Aquatic Weed Control Short Course, May 1 - 5, 2006, Coral Springs, FL. http://conference.ifas.ufl.edu/aw/

14th International Conference on Aquatic Invasive Species, May 14-19, 2006, Key Biscayne (Miami), FL. www.icais.org/

Florida Native Plant Society (FNPS), Annual Conference, May 18-21, 2006, Daytona Beach, FL. www.fnps.org

Southeast Exotic Pest Plant Council (SE-EPPC), Annual Conference, May 23-25, Raleigh, NC. www.se-eppc.org

Weeds Across Borders 2006, May 25-28, 2006, Hermosillo, Sonora, Mexico. www.desertmuseum.org/borderweeds/

Florida Lake Management Society (FLMS), Annual Conference, June 5-8, 2006, St. Augustine, FL. www.flms.net

Aquatic Plant Management Society (APMS), Annual Meeting, July 16-19, 2006, Portland, OR. www.apms.org

14th North American Weed Management Association (NAWMA) Conference, Sept. 18-21st, 2006, Calgary, Alberta, Canada. www.nawma.org

Florida Aquatic Plant Management Society (FAPMS), Annual Meeting, Oct. 30 - Nov. 2, 2006, St. Petersburg, FL. www.fapms.org

More of *Mary's pics* ~

* **Indigenous cultivation and conservation of totora (*Schoenoplectus californicus*, Cyperaceae) in Peru.** By S.A. Banack, X.J. Rondon, and W. Diaz-Huamanchumo. 2004. *Economic Botany 58(1):11-20.*

The people around Lake Titicaca are intensively cultivating this plant as natural populations of the plant are being reduced. "Totoro" continues to be used to make walls, fences, mats, ceiling and little boats. In fact, the little boats are the only boats observed used daily for fishing.

* **Cogongrass *(Imperata cylindrica)* - biology, ecology and management.** By G.E. MacDonald. 2004. *Critical Reviews in Plant Sciences 23(5):367-380.*

This is a thorough review of the literature on all aspects of one of Florida's most invasive non-native plants.

* **Kudzu *(Pueraria montana)*: History, physiology, and ecology combine to make a major ecosystem threat.** By I.N. Forseth and A.F. Innis. *Critical Reviews in Plant Sciences 23(5):401-413.*

In the first half of the 20th century, the government provided more than 85 million seedlings of kudzu to landowners in the southeastern United States. Today, kudzu covers more than 7 million acres; it spreads by more than 100,000 acres per year. This paper discusses its ecology and physiology.

* **The truth about invasive species.** By A. Burdick. 2005. *Discover Magazine, May 2005.*

Are invasive species really so bad? The author believes new research reveals nature is far more resilient than we thought - maybe we can "stop worrying and learn to love ecological intruders."

* **The human dimensions of invasive woody plants.** By P. Binggeli. 2004. In: The Great Reshuffling - Human Dimensions of Invasive Alien Species, ed. by J.A. McNeely, pp. 145-159. IUCN, Gland.

Quick! Name seven purposes of introductions of woody plants. Give up? Read this...

* **Invasion of *Agave* species (Agavaceae) in south-east Spain: invader demographic parameters and impacts on native species.** 2004. By E.I. Badano and F.I. Pugnaire. *Diversity and Distributions 10(5-6):493-500.*

Agave species were introduced as ornamental plants to Spain in the 1940s, but what has contributed to their large population increases and spread? And what are their effects on native species and communities?

* ***Potamogeton* taxa proposed by J.F. Wolfgang and his collaborators.** By Z. Kaplan and J. Zalewska-Galosz. 2004. *Taxon 53(4):1033-1041.*

A discussion of the taxonomy of 12 species of Polish pondweeds.

Editor's Note: In the last issue of AQUAPHYTE (Vol. 25(1), Spring 2005, pg. 6) it was stated that Dr. Robert Henry is retired curator of the RM Myers Herbarium at Ohio State University. The RM Myers Herbarium is at Western Illinois University.

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AQUAPHYTE

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AQUAPHYTE is sent to managers, researchers and agencies in 71 countries around the world. Comments, announcements, news items and other information relevant to aquatic and invasive plant research are solicited.

Inclusion in **AQUAPHYTE** does not constitute endorsement, nor does exclusion represent criticism, of any item, organization, individual, or institution by the University of Florida.